COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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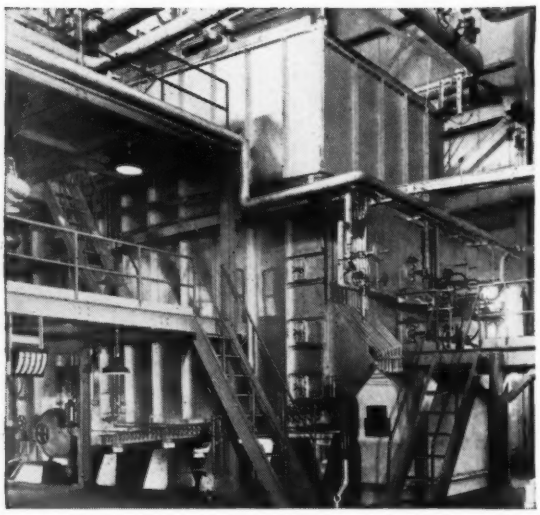
Photo by Stuart Umin

Sunset on the Harlem; see p. 60

First Marshall Plan Power Project Placed in Service at Genoa ▸

Ignition Arches for Single-Retort Stokers ▸

The VU Story for 1951



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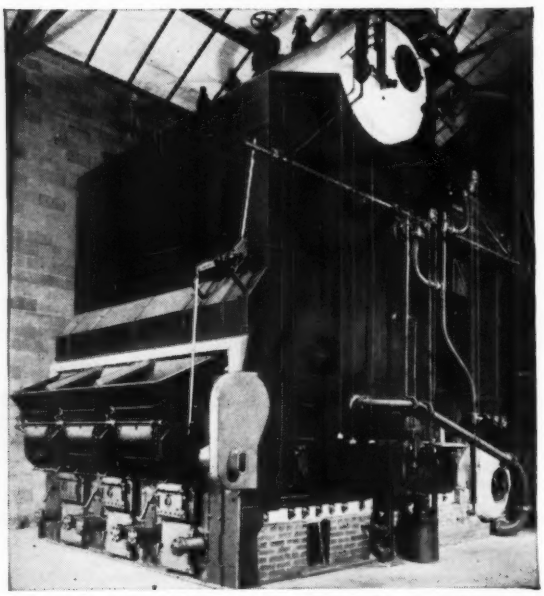

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GEOGRAPHICAL — Units ordered during 1951 will be installed in 27 states, in seven Latin American countries and in Africa, Arabia, Australia, Canada, Israel and Spain.

INDUSTRIES — Automobile, Brewing, Building Materials, Cement, Chemical, Food Products, Government, Institutions, Lumber, Machinery, Metal Mfg., Mining, Paper, Petroleum, Public Utilities, Railroads, Rayon, Rubber, Shipbuilding, Soap, Sugar and miscellaneous manufacturing.

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COMBUSTION

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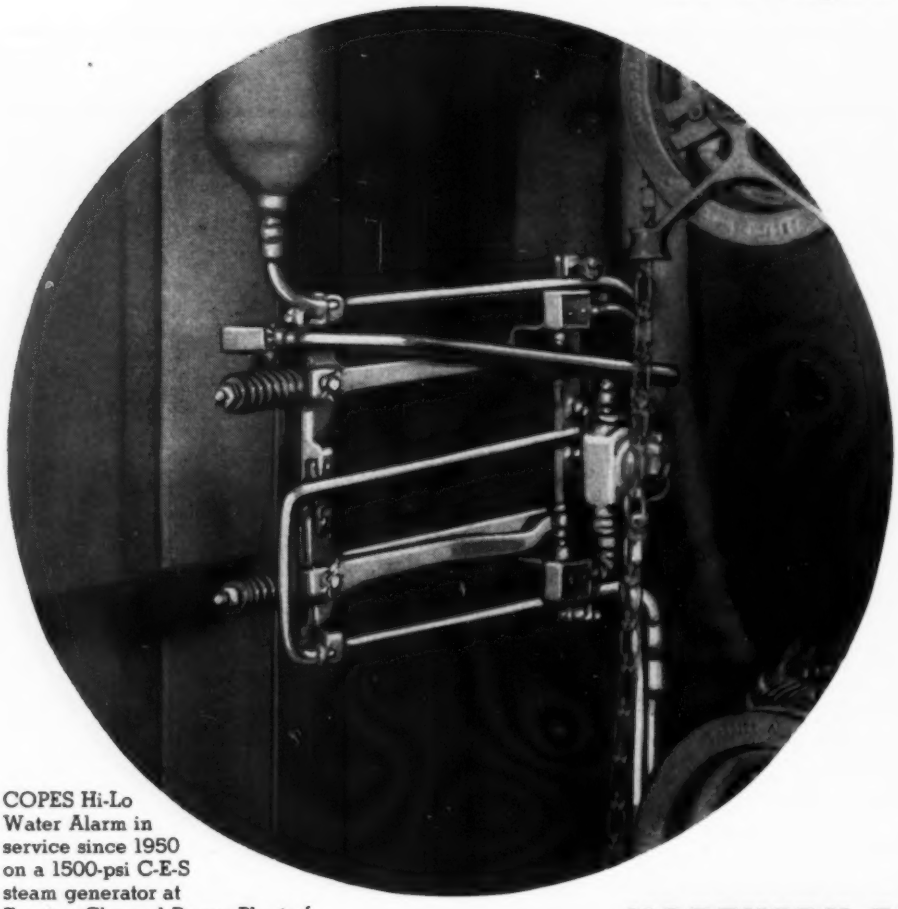

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Editorials

The Mechanics of Contaminant Combination

At the Seventh Air Pollution Abatement Conference of the Manufacturing Chemists' Association held recently in New York City, Dr. John H. Foulger of the Du Pont Company commented that most studies of maximum allowable concentrations of atmospheric contaminants have been based upon the effects of a single contaminant. Of course, there are practical reasons for this from a research viewpoint, such as cost and complexity of studies. Nevertheless, an important question remains unanswered: Can it be that two or three or more contaminants, each present in the atmosphere in a concentration too low to cause physiological damage, are able to combine with resulting harmful effects?

One possibility, suggested by Dr. Foulger, is that the effects of contaminants may not be additive in an arithmetic but in an exponential sense. In other words, unsuspected danger may be present in combinations of contaminants. This condition may be further aggravated by the presence of particulate matter or minute moisture droplets upon which the contaminants may be adsorbed and later deposited far down in the human respiratory tract.

Here is an instance where cooperative research involving work in the medical sciences, physics, chemistry and engineering seems well advised. Efforts to combat harmful effects of air pollution can be made more beneficial if the fundamentals of contaminant-combination mechanics are better understood.

Power Under the Marshall Plan

During the present year a number of large steam power plants, or extensions, will have been placed in service in Italy as a result of Marshall Plan financing. That at Genoa, which is described in this issue, will be followed by those at Piacenza, Tavazzano, Torino and Rome. Others are being constructed without aid from the United States.

This large increase in Italy's electric power capacity is certain to be reflected in a higher standard of living for much of the population through increased industrial production, more employment and wider use of electrical equipment and appliances of all kinds. Such improvement in economic conditions should also make for improved political stability.

There seems to be confusion in the minds of some as to the functioning of Marshall Plan aid. Therefore, it is in order to point out that the assistance is not extended directly to the utilities concerned but rather to the Governments in the form of credits. The utilities borrow the money from their government at interest, with the loans paid off in fifteen to twenty years. These payments, in turn, are utilized by the Governments for various public projects. By such an arrangement the dollar credit in the countries involved is not jeopardized.

What's New in Steam Temperatures?

Last year Great Britain celebrated achievements in science and technology of the past hundred years in an exhibition known as the Festival of Britain. Out of this celebration came a historical book entitled "A Century of Technology" in which eighteen leaders in industry and engineering appraised the past and attempted to foresee something of the future.

With the very real possibility of steam temperatures in central stations reaching the 1200 F mark in the next few years, one item in this historical study deserves mention. Although the steam-driven automobile is merely a museum curiosity today, a Frenchman by the name of Serpollet did some outstanding pioneering in 1906 by employing steam conditions of 1200 psig, 1200 F. Using a flash-type boiler and a simple-expansion single-acting multi-cylinder poppet-valved engine, he was able to obtain an economy of 0.8 pound of oil per brake horsepower-hour and a speed in excess of 90 miles per hour.

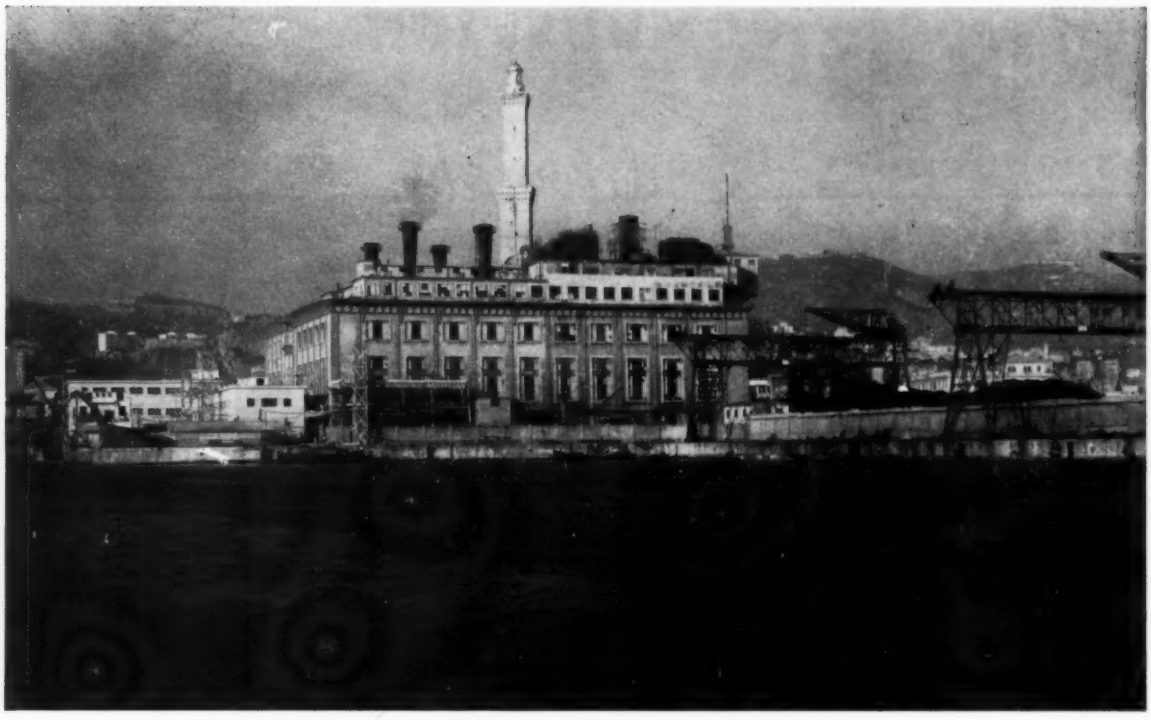
Sometimes in our zeal for present-day accomplishments it is well to look back and see what engineers with far less knowledge of the properties of materials were able to achieve.

A Superimposed Load

A recent radio broadcast from Washington, under the sponsorship of the Bituminous Coal Institute, commented on the rapidly growing use of electricity for home heating. It claimed that there are already seventy thousand electrically heated homes in the Tennessee Valley and that approximately ninety per cent of the new homes now being built in a number of southern cities, such as Nashville, Chattanooga and Knoxville, are heated entirely by electricity. The point emphasized by the broadcast was, of course, that this trend represented increased use of bituminous coal, since water power in this region had already been developed almost up to its potentialities.

Herein may lie an important factor in the unprecedented growth of electrical demand in certain areas; for, unlike many electrical appliances that represent more or less off-peak demand, the residential heating load extends over the greater part of the twenty-four hours and thus is superimposed on industrial load peaks.

If such a condition should prevail over wide areas, it would not be conducive to easing the power situation at a time when defense needs have first call on available capacity and material shortages are affecting power equipment deliveries.



General view of station from Genoa harbor.

First Marshall Plan Power Project Placed in Service

A brief description of the 125,000-kw extension to the Genoa Steam Station of the Italian Edison Company, the first unit of which was placed in service with fitting ceremonies on February 24. This is the first of 720,000 kw of steam power being added to Italy's capacity under a 64-million dollar financing program ECA.

ON February 24 the first Marshall Plan-financed steam-electric installation was formally placed in service. This was the first 62,500-kw section of a 125,000-kw extension to the Genoa Station of Societa Edison (Italian Edison Company). This installation is also the first of some 720,000 kw of steam-electric power capacity being added to Italy's overall capacity under a 64-million dollar financing program of the Economic Cooperation Administration (since renamed the Mutual Security Agency). It is expected that all this new capacity will be brought into service during the remainder of the present year or early in 1953. This should add greatly to Italy's economic strength and, in turn, fortify her national defense.

Actually, the figure of 720,000 kw represents less than a fifth of the Italian postwar power construction program which totals over 4 million kilowatts. As the Marshall Plan dollar aid represents about one-half of the cost of the MSA projects, the dollar aid will pay for roughly ten per cent of the new power capacity being built in Italy.

In excess of 1,200,000 kw of new capacity was placed in service, through Italian financing, in 1949–1951, making the present total for the country approximately 8,500,000 kw. Plants now under construction will raise this figure to about 10,500,000 kw.

This is in contrast to a total effective capacity that existed in 1938 of about 5 million kilowatts. Plant construction came to a standstill from 1940 to 1946, and for two or three years thereafter activity was confined largely to the reconstruction of power plants damaged during the war.

Serious droughts during the postwar years showed that Italy was too dependent on water power; hence officials of Italian utilities, the Ministry of Public Works, and ECA agreed that emphasis should be placed on steam plants in the expansion program. The resulting goal represents a ratio of 25 per cent steam capacity and 75 per cent hydroelectric plants, compared to a 1951 ratio of 14 and 86 per cent, respectively.

The Societa Edison is a privately owned utility which, under the Marshall Plan set-up, borrowed the necessary money, at interest, from the Italian Government to which ECA funds were supplied. Much of the large high-pressure equipment was purchased in the United States,

supplemented by locally available materials. The company also paid all construction expense.

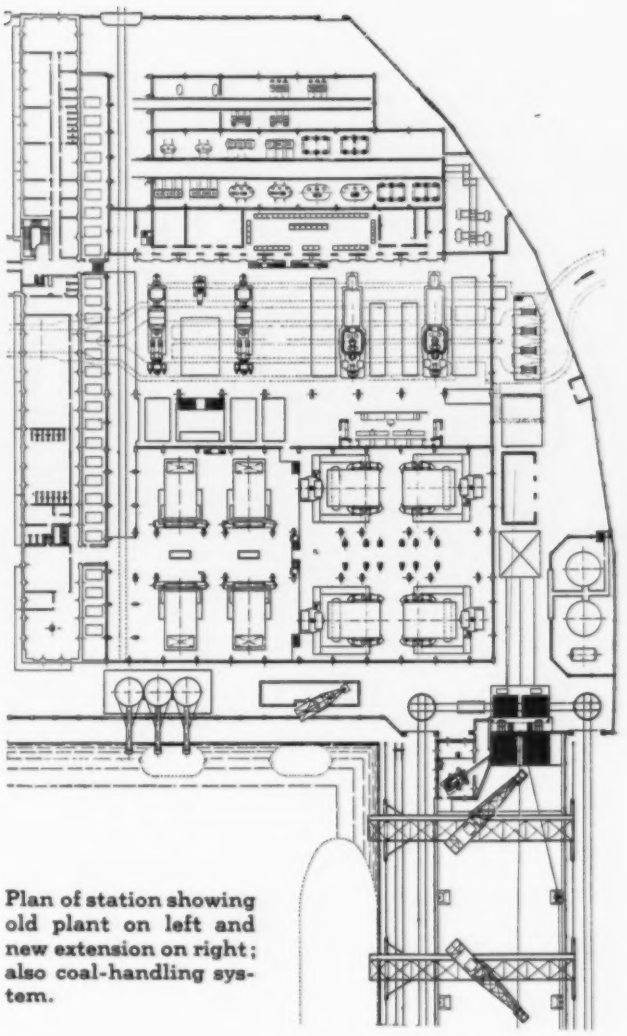
A second 60,000-kw unit is nearing completion and is scheduled for operation in April.

The original station was laid out for two 25,000-kw units with separately driven exciters and building space for an ultimate 200,000 kw. Construction was started in 1927 and two years later the first of these 25,000-kw units was placed in service, followed shortly thereafter by the second. This steam capacity of 50,000 kw supplemented hydro power on the system.

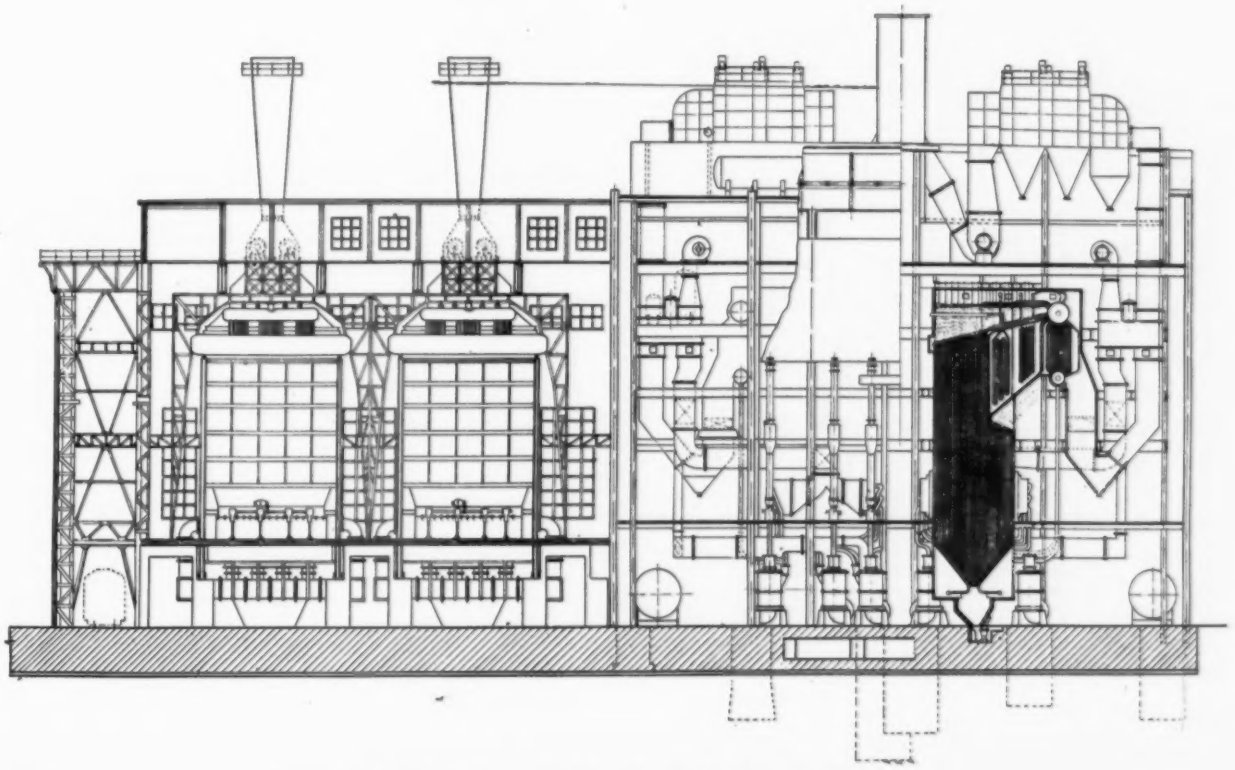
The four early boilers of 198,000 lb per hr each were stoker-fired and further expansion was then limited by the necessity of importing foreign coal. However, rather than place too much dependence on imported coal, hydro power was expanded.

After the war it became most important to turn attention to steam for further expansion, inasmuch as most of the economically developable hydro sites had been exploited. Abundant supplies of low-grade coal were available in Sardinia, Italy's Mediterranean island, the use of which was desirable as it meant that scarce foreign exchange would not have to be employed to import fuel. This coal, which analyzes around 15 per cent ash, 32 per cent volatile, 12 per cent moisture, 2.8 per cent sulfur and 2000 F ash-fusion temperature, with a heating value of about 11,500 Btu per lb, was found to be readily burnable in pulverized form in a dry-bottom furnace.

Gibbs & Hill, New York consulting engineers, supervised the design and construction of the new 120,000-kw extension and a number of well-known American firms supplied major equipment. These included Combustion Engineering-Superheater, Inc., who furnished the four boilers, and Westingthouse Electric Corporation, who furnished the two turbine-generators.



Plan of station showing old plant on left and new extension on right; also coal-handling system.



Section through old and new boiler rooms.

The steam generating units here shown in the boiler-room cross-section are each rated at a maximum continuous output of 320,000 lb per hr and are designed to burn coal or oil with tangential firing and vertically tilting burners. These, with supplemental desuperheating, control the steam temperature. Steam conditions are 900 psig and 905 F at the superheater outlet with feedwater to the economizer at 445 F. Each unit has a Ljungstrom regenerative type air preheater and a Western Precipitation combination eletrostatic and cyclone precipitator.

Each of the turbine-generators, although nominally rated at 50,000 kw, has an actual capability of 62,500 kw. The turbines are of the tandem-compound type with double-flow low-pressure elements.

Two boilers, one turbine-generator and one transformer, together with the necessary auxiliaries, form a complete unit. The selection of two boilers per turbine was motivated by a desire for maximum flexibility since there is low load operation part of the time and adequate space was already existent. The calculated station heat rate is said to be around 12,000 Btu per kwhr.

An idea of the steam cycle conditions may be gained from the flow diagram.

Coal may be delivered either by ships or by railroad cars and is unloaded to storage by a coal bridge with boom and grab bucket (see plan). From storage the coal is elevated to a belt conveyor which distributes over the bunkers. Outside silos provide storage for ash which is subsequently removed by barge. The coal storage capacity is 25,000 tons.

The new extension to the plant also includes a reinforced concrete two-story service building to the rear of the main building, in which are housed administrative offices, laboratory, drafting room, rest rooms, machine shop, cafeteria, etc.

A glimpse of the very impressive official dedication on February 24 is afforded by the following excerpts from a vivid description in a letter received from one of the guests at the ceremony which indicates the importance attaching to the occasion.

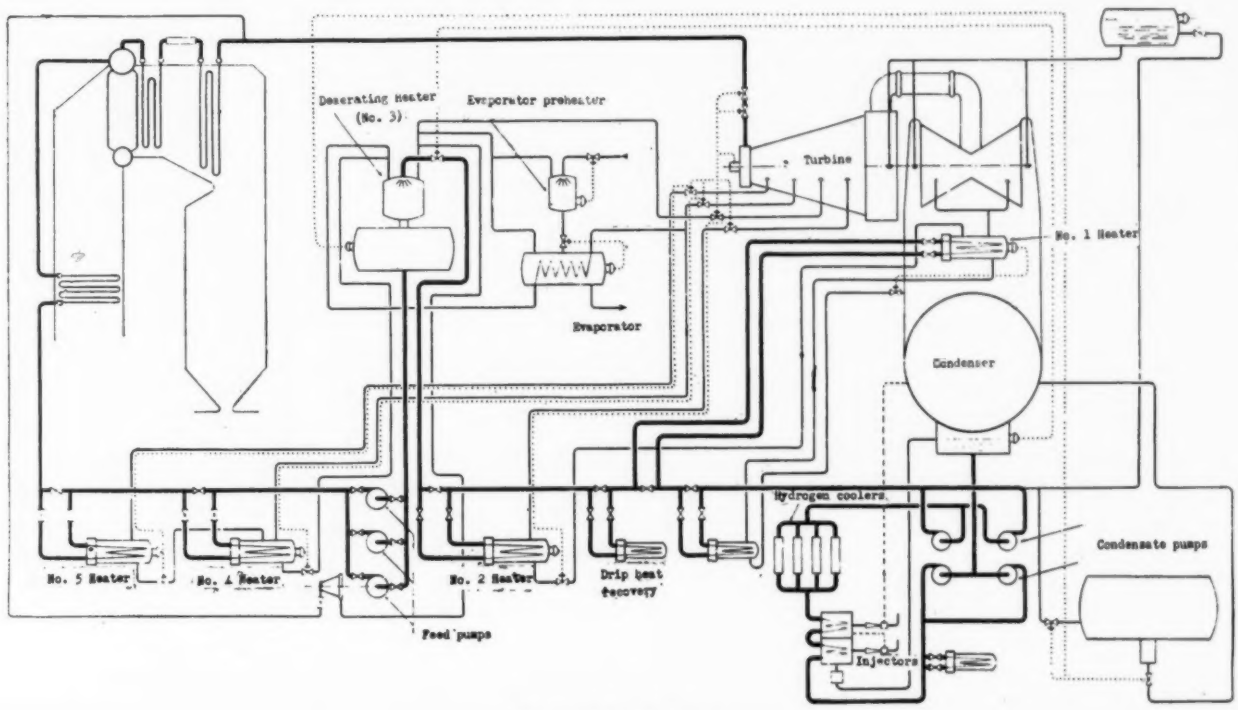
"The affair was held in the main turbine hall with about 300 prominent guests present. On the wall back of the small raised speaker's platform was a huge map of the Edison System. Steam and hydro plants were indicated by relatively large different colored lights with the transmission lines shown by smaller lights, and projected stations and lines also indicated in blending colors. Genoa Station was designated by a flashing purple-red light. The map had red velvet side drops about 50 ft high by 30 ft wide upon which were nested on each side a shield of American flags; and the back drop was bordered by Italian colors running vertically.

"Standing behind the speaker were six Carabienerie police in full-dress uniform comprising blue-tailed jackets, blue trousers with broad white stripe, white cross-webbing and a belt with large silver breast buckle where the webbing crossed, a silver sword and large Napoleonic hat of shining leather and a 2-ft red plume. The turbine-generator was similarly guarded.

"Following a period of intense quiet, Dr. P. Ferrerio, President of the Company, opened the dedication with a speech in which he stressed the growth of the Company and the fact that Societa Edison is one of the last fully private utilities in that country.

"The next speaker, Mr. Dayton of ECA, representing the U. S. A., warned against communism and pointed out that the installation was a tangible symbol of America's goodwill toward Italy. He pointed out that Societa Edison was paying for this 28 million dollar project with money borrowed from the Italian Government which was the recipient of the ECA funds. The interest on the loan paid by the Company to the Italian Government is being employed for new housing projects.

"The top group then accompanied the Bishop and his retinue over to the first of the turbine-generators

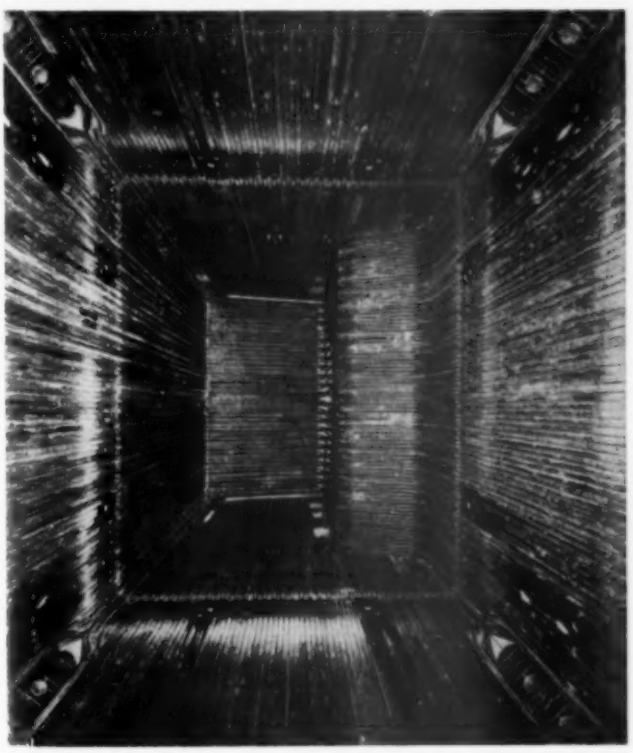


Heat cycle diagram.

View of Genoa from roof of power plant

which was blessed with solemnity. Following this the turbine was started by the president of the Societa Edison.

"The group then proceeded through the control room (where they spent much time watching the televised water glass) and then to the boiler room where one of the C-E boilers was in operation on oil. Here they were much interested in the scene-in-action model depicting the operation of the boiler and demonstrating how the vertically tilting tangential burners function to vary the effective furnace volume at different loads for control of exit gas temperature.



Looking into furnace with tangential tilting-type burners in each corner

Interior of drum showing internals.

"The party then broke up, the top officials going to luncheon at the swank Columbia Hotel, the next echelon of about 200 to another hotel and the plant personnel to the Company cafeteria.

"The only individual mentioned by the President in his speech was Dott. Ing. Franco Castelli, Direttore Servizio Termico, which may be regarded as a fine compliment to his ability and integrity.

"This modern plant, located on the waterfront of the greatest port on the Mediterranean under the spectacular hills of Genoa, with the snow-capped Apennines in the distance, is but a mile away from the house Genoa gave to Columbus after he discovered America."

Chemical Cleaning Applied to Controlled Circulation Boilers

By W. D. BISSELL
Montaup Electric Company
and
M. M. SORENSON
Dowell Incorporated

With eighteen large controlled circulating units, aggregating nearly 17 million pounds of steam capacity, now under construction or on order the chemical cleaning procedure as developed from experience with the pioneer Montaup installation holds special interest. This is described in detail.

THE controlled circulation boiler of the Somerset Station of the Montaup Electric Co. was put into operation in October 1942, and was the first unit of this type to be installed in this country. Its various features and operating performance have been the subject of several ASME papers and articles (see bibliography), and its installation was almost coincident with the inception of chemical cleaning of large, high-pressure boilers in the East.

Fundamentally, this type of boiler differs from a natural circulation boiler in that circulating pumps are installed between the downcomers and the bottom furnace wall header. Orifices in this unit are inserted in the inlet header at the entrance to each circuit, in order to maintain a predetermined proportion of the total circulation in the circuits.

The arrangement of the tubes, their relatively small diameter and the presence of orifices constitute no problem in the flow of cleaning solvents. The same system that maintains a uniform distribution and flow of boiler water throughout the boiler assures a similar distribution of cleaning chemicals, and any sample taken may be regarded as representative of conditions at all points of the system.

The Montaup unit was not given an initial acid wash for the removal of mill scale, as experience in treating feed and boiler water for pressures of around 2000 psi was limited in 1942. The first chemical cleaning took place in April 1943.

Following the first chemical cleaning of the boilers, it became apparent that use of the circulating pumps would be desirable for future cleaning operations. The small volume of the tubes, together with the vagaries of scale deposition, had caused the solvent to become spent in certain areas, while remaining relatively fresh in others. Also, the temperature varied. This led to incomplete scale removal in some areas, probably including those most in need of bare metal conditions.

Accordingly, when the need for a second cleaning was indicated the following December, the original hesitancy to use the circulating pumps for this purpose was overcome by the experience gained in the interim with other equipment in the field. It was found that, by operating one pump at half speed for 3 min out of 30, sufficient circulation was attained to establish satisfactory conditions of concentration and temperature throughout the system. It may be mentioned that this pump, which had been designed with no such service in view, continued to be used for several more cleanings without incurring any discernible damage.

Fig. 1 is a reproduction of a temperature chart showing how the tube temperatures are stablized by running one pump, 3 to 5 min every hour—a procedure that has become standard. There is enough heat in the drums and headers to maintain adequate solvent temperature throughout the soaking period. This "reservoir" also serves to renew the spent solvent in the tubes, thus equalizing the concentration throughout the circuits.

Later on, it was found that dilution of the solvent was taking place from hot water entering through the water seal in the circulating pumps. This necessitated blowing down the solution several times during the cleaning period, which required the presence of a pump operator. The circulating pump seals then were redesigned and the trouble ceased.

However, in the meantime, a low-priced 600-gpm centrifugal pump had been installed for use during cleaning operations. Use of this pump avoids not only the possibility of acid dilution but the necessity of a pump operator being present during cleaning. It also expedites disposal of the solvent from the boiler, which alone may save enough time to compensate for its cost.

The small blowdown opening which at first was employed for filling and draining made for a lengthy operation—some 36 to 40 hr for a complete cleaning job. Consequently, two 4-in. nozzles were welded into the discharge and suction manifolds. The lines from these nozzles are blanked off during regular operation, being connected to the solvent circulating pump only during cleaning. A considerable saving in time resulted from this change, as shown by the following tabulation of single-stage jobs, which require only one rinse:

	Before	After
Filling time	2 hr	21 min
Draining time	2 hr	45 min
Total cleaning time	36 hr	20 hr

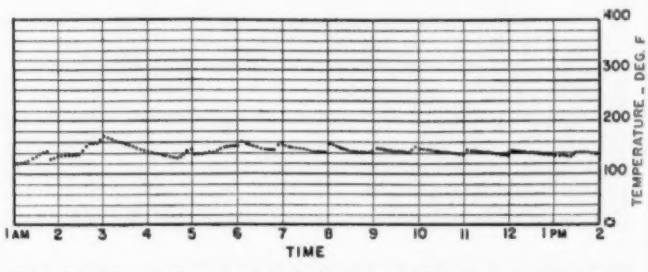


Fig. 1—Chart showing stabilization of tube temperatures

The preliminary preparation consists of the following steps:

1. Remove blanks and install two chemical filling connections.
2. Make temporary connection to chemical truck.
3. Connect vent line to atmosphere.
4. Install temporary gage glass, if type of solvent is harmful to mica.
5. Fill unit to operating level with hot water.

Next, one of the boiler circulating pumps is operated until an even distribution of temperature is obtained throughout the unit; following which the pump is shut down and the pump casing is drained. At this point, the boiler, also, is drained.

Solvent then is pumped through the blender which mixes steam, water and the concentrated solvent. The piping and valve locations should be close together, for close control, somewhat as indicated in Fig. 3.

Filling of the unit is continued until the solvent enters the upper drum. It is then allowed to soak, with 3-to 5-min circulation periods at hourly intervals. Solvent concentration checks are made after each circulation period. After the prescribed soaking time, the boiler is rapidly drained and refilled with water at 140 F, and the circulating pump is again operated for 5 min. The boiler then is drained. Here it should be pointed out that no one should enter the drum after acid washing, until the boiler has been filled with water and drained.

There are several procedures for post-neutralizing and flushing, the choice being contingent upon the intended use of the boiler—whether immediate service, short standby or several weeks outage.

All such cleaning systems, as have been devised for natural circulation boilers, are also well adapted to this type of unit, with comparable saving in time and effectiveness of application.

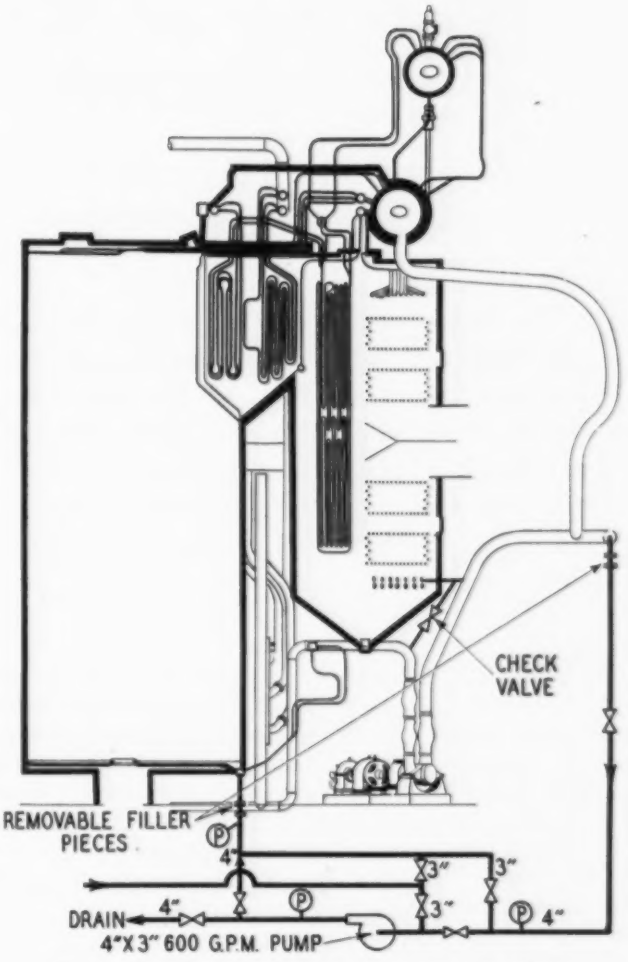


Fig. 3—Outline of boiler showing valve locations

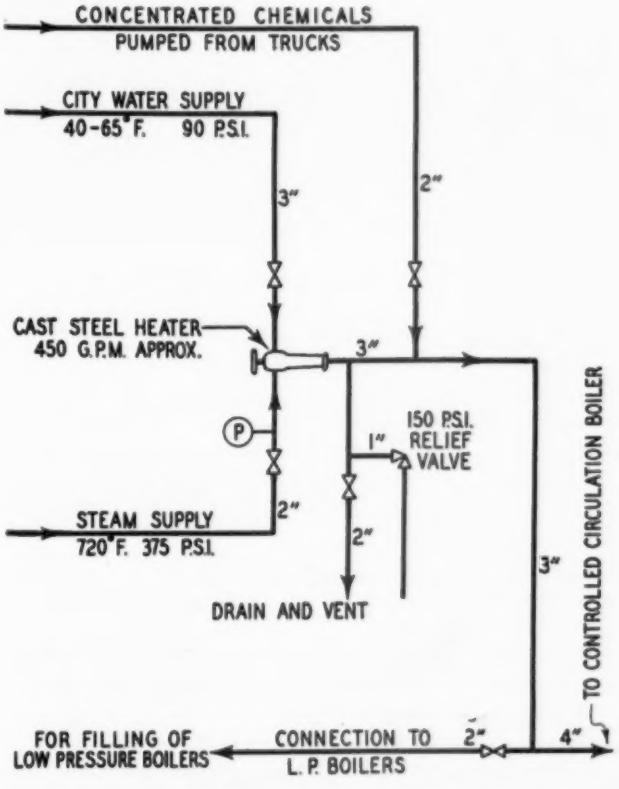


Fig. 2—Diagram of connections

The relative frequency of cleaning this unit and the variety of solvents used can be attributed largely to the amount of investigational work that was being conducted, particularly in water conditioning, as well as the insistence by management that high availability be maintained. This led to a number of dissimilar materials being encountered, including those high in carbonaceous matter during one period of water treatment; also silicates and copper. It should be mentioned that considerable pioneering was done in the field of chemical cleaning, because this was the first large capacity, high-pressure unit in which such removal of deposits was carried out.

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Welding of Machinery, Pressure Vessels and Piping

By R. E. LORENTZ, JR.

Metallurgist, Combustion Engineering-Superheater, Inc.

The following is based on a talk before the Baltimore Chapter of The American Welding Society on February 13, 1952. It reviews the formulation of welding codes, briefly describes various welding procedures and discusses inspection methods. Metallurgical considerations are also touched upon.

LARGE welded pressure vessels with maximum shell thicknesses of approximately 6 in. are currently being produced. Operating pressures for large diameter vessels of this type are as high as 2600 psig and temperatures range from below minus 350 F up to the maximum temperature which the various analyses of metal will withstand. Environments may consist of highly corrosive materials or lethal substances. Loading may be static, dynamic or of a shock type.

Smaller diameter pressure vessels or piping with slightly lesser maximum shell thicknesses are currently being fabricated. Operating pressures for these smaller diameter vessels may be as high as 30,000 psig.

Service requirements for certain machinery parts may be similarly high as regards to temperature, corrosive environment, and imposed stresses. Additional requirements of abrasion or wear resistance, resistance to galling, and many other services must be considered for this type of weldment.

Safety

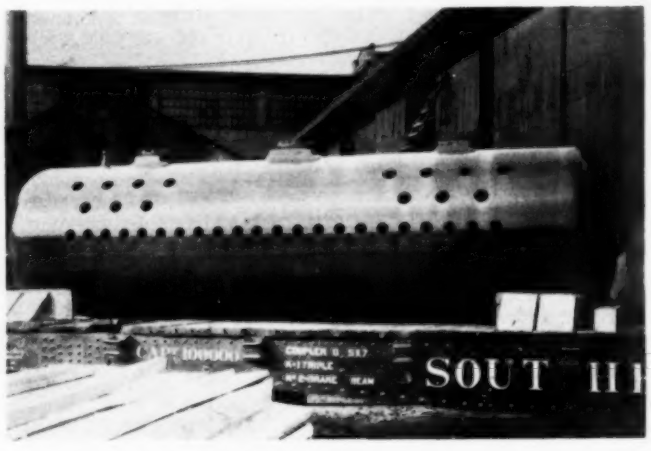
Failure of a weld in a machinery, pipe or pressure-pressed weldment could result in loss of life and damage to property. The risk involved by such failures varies considerably with different services. Failure of a weld in a pressure vessel containing water at high temperature and pressure or explosive fluid, for instance, can be most expensive to life and property. Boiler drums containing water at high temperature and pressure may be cited to illustrate this, particularly the following information taken from a monthly bulletin of The Hartford Bureau of Insurance and Inspection:

In 1865 a horizontal return-tubular boiler in the Mississippi steamboat *Sultana* blew up and 1238 persons were killed. In 1894 at a coal mine in Pennsylvania, 27 out of a line of 36 boilers went off like a string of firecrackers and did enormous property damage. From October 1, 1867 to January 1, 1909, 10,051 boiler explosions took place, killing 10,884 persons and injuring 15,634 others.

The energy present in an ordinary domestic type hot-water heater of 30 gal capacity is sufficient, if it were suddenly released by splitting because of failure of a relief valve, to blow the tank weighing about 100 lb., seven miles straight up. The energy present in the mammoth boiler drums operating at much higher temperatures is enormous.

For these reasons the standards of weld quality in this type of construction as well as with all those services potentially hazardous to life or property approach the ideal of perfection.

In 1911, Colonel E. D. Meier, for several years previous a member of the American Boiler Manufacturers Association, and much alarmed by the poor records of boiler service, became president of the ASME and recommended the formation of "A Committee to Formulate Standard Specifications for the Construction of Boilers and Other Pressure Vessels and for Their Care in Service." Today, this is better known as the "ASME Boiler Code Committee." This committee, comprised of mill representatives, fabricators, and users of pressure vessels, reached agreement in 1914 and published its first safety rules and regulations in 1915. It has remained active and kept up with changing conditions. When the need for higher pressures and greater thicknesses of material became sufficient, and with the development of coated rod welding and X-ray non-destructive examination, this committee wrote rules for welded construction.

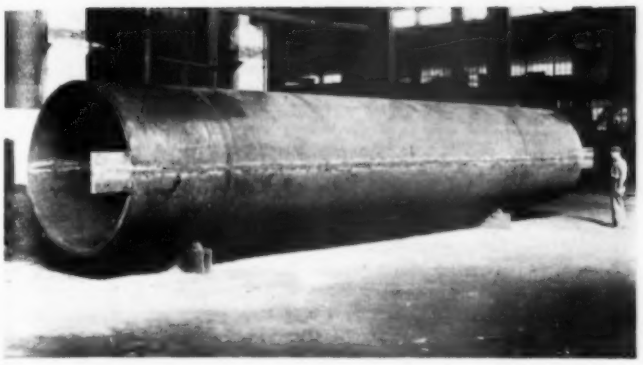


First welded drum built to ASME Code

The first all-welded boiler drum built to these standards was constructed in 1931 by the company with which the writer is associated.

The United States Navy was similarly active in formulating safety rules and built its first boiler drum to these requirements in 1930.

Today, in addition to the above safety rules, there are also rules formulated by the American Petroleum Institute, the United States Coast Guard, the American Bur-



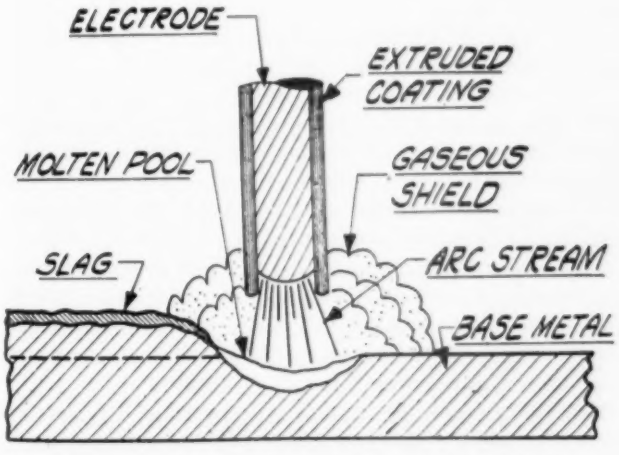
Test plate attached to longitudinal seam

eau of Shipping, the American Standards Association, Lloyds' Register of Shipping and by various States and Cities.

The safety codes to which pressure vessels are built permit several classes of vessels, depending upon service requirements. Rules for the construction of the highest class pressure vessels are essentially the same in the various codes and require X-ray examination of all welded seams and stress-relief heat treatment of the completed vessels. In addition, they require physical tests to be made of the weld metal and joint on samples taken from a test plate welded as a continuation of the longitudinal seam of each vessel. Where there is no longitudinal seam, a separately welded test plate is employed using an identical welding procedure.

These codes also specify maximum operating temperatures for various materials and allowable design stresses at various temperatures for the different materials. The maximum allowable design stress is generally $^1/_4$ or $^1/_5$ of the tensile strength of the material at relatively low temperatures. At temperatures where "creep" or "very gradual stretching of the metal under load," becomes operative the maximum allowable stresses are 80 per cent of the stress required to produce a creep rate of 0.01 per cent per 1000 hr, and the allowable stress cannot exceed 50 per cent of the stress to produce rupture at the end of 100,000 hr. Designers generally limit their stresses somewhat below these maximum amounts.

The codes also specify methods for qualification of welders to insure that properly trained men are used.



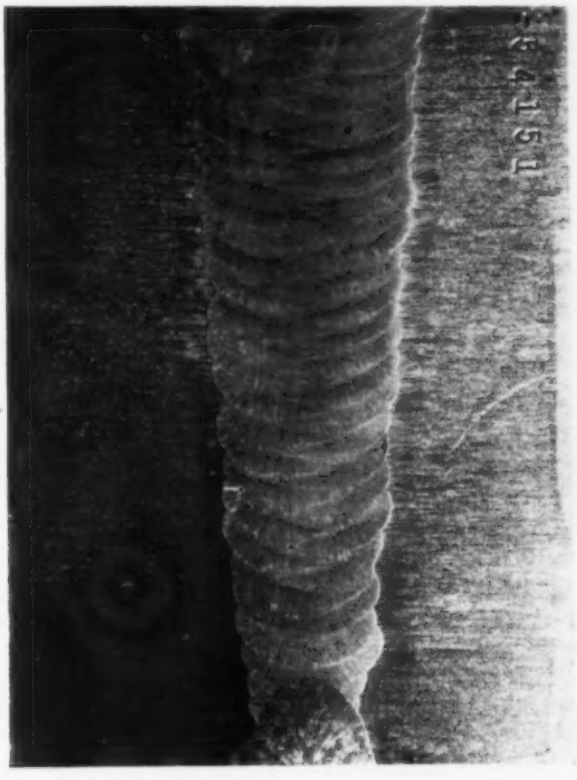
Sketch of metal arc-coated electrode welding

The Welding Procedure

When two metals are to be joined the welding engineer has a choice of several different welding processes, as well as a choice of several different welding electrodes. He must choose a proper weld groove or joint design and determine whether the materials to be welded require preheat. In many cases he must decide on postheat temperatures and time ranges. The writing of these and other conditions constitutes a "welding procedure" or "joint welding procedure." The welding procedures for machinery weldments, pipe weldments or pressure-vessel weldments may be, and usually are, essentially the same. Different methods of non-destructive testing, however, are usually used for machinery, pipe and pressure vessel weldments. The testing procedures are not usually a part of the "welding procedure," but rather a part of the code or customer specification to which the weldment is built.

Butt Weld Grooves and Applicable Welding and Inspection Methods

The basic type of weld groove is the double-welded butt joint. Such joints, welded from both sides, offer the best assurance of sound metal free of cracks, porosity, or slag and are used where maximum strength is required or where shock, fatigue, or plastic deformation may occur. Both surfaces may be ground, blending the weld metal smoothly with the base metal, eliminating undercutting, or any notches which might serve to act as stress concentrations. A single-welded butt joint made from one side against a backing strip which is later removed and any defects or stress concentrations repaired is equally satisfactory. Both of these type joints are



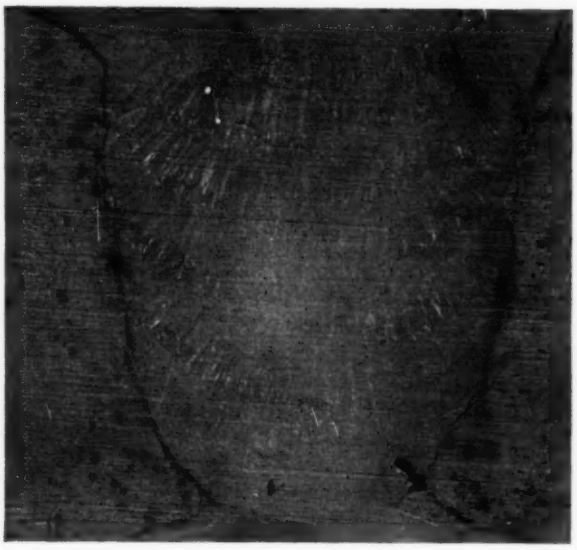
Weld of 5 1/2-in. plate, macro-coated rod coil with inside pass submerged arc

readily examined by X-ray or a radioactive source. Where welding is done from one side against a backing strip and the backing strip left on because of lack of access there is a possibility of defects occurring against the backing strip. If the backing strip is wider than the weld groove an exograph or gammagraph can be readily interpreted. If the backing strip is too narrow the outline of its edges on the negative may mask out defects. Properly X-rayed, this type of groove is considered by most codes as having efficiencies equivalent to those previously mentioned. Where a backing strip left in place is objectionable and access for removing it is lacking, welding is oftentimes done against a copper backup with care being taken not to fuse any copper into the added metal. This is readily done as long as a molten pool is always kept between the arc and the copper. Other materials in place of the copper, such as ceramics, are sometimes used.

In the interest of economy many fabricators inspect the raw materials in order to minimize chip outs and rewelds. For instance, it is fairly standard practice, with such joints to test the plate edges for laminations that would cause weld defects, and to remove these before any expensive operations are performed, such as forming and machining. Ultrasonic testing equipment is very useful for this purpose. It passes a sound wave through the metal and if defects are present it echoes back from them giving an indication on an oscilloscope screen. Metals showing excessive defects can then be rejected or repaired. Another often-used testing method tests the surface only and can detect laminations on the surfaces of weld grooves. This testing method is known as magnetic particle testing. It can be used only on magnetic metals. The metal is magnetized by this equipment and a ferromagnetic powder blown on the surface. The powder is preferentially attached to laminated areas, or other defects. Such areas can be repaired. On non-magnetic materials other procedures such as fluorescent penetrant or oil power testing can be applied. All of these testing procedures can be also applied to testing of welds for defects. They are used for various applications.

Showing cracked weld with and without application of magnetic particle test

The X-ray or radioactive source examination of welds does not always show up serious defects. For example: In order for the X-ray to show a defect on the film the defect must have a certain thickness or depth in a direction parallel to the X-ray beam. Practically all the defects inherent in welding a butt joint have such depth. Slag, porosity, lack of penetration, lack of fusion and, generally, cracks have depth in the required direction. Generally, a crack caused by a lamination or inclusion will turn up along the path of the columnar crystals formed during solidification of the pass. Where small passes of weld metal are being used the columnar crystals will turn upward perpendicular to the surface very quickly and the crack will have appreciable depth in the direction of the X-ray beam. Where much larger passes are used, however, the columnar grains may grow at an angle 30 to 45 deg from the perpendicular. A crack oriented at this angle, even though very serious, would not show in an X-ray made in the regular procedure.



Weld defect starting from plate inclusion in multi-layer weld

For this reason the very heavy passes possible with the submerged arc welding procedure are not generally being used.

Today, the majority of welding employs automatic or semi-automatic welding procedures. Coated, coiled electrodes in which the current is brought to the underlying rod by means of smaller wires in contact with it and extending beyond the coating or by slitting the coating with saws and bringing electrical contact fingers into these slits are widely used. The submerged-arc process, using a coil of bare rod and a powdered flux which is fed around the arc and hides it from view, is also widely used.

On butt welds in thin materials atomic hydrogen and an inert arc, with non-consumable electrodes and adding metal through filler rods which are melted under the arc, are widely used. These processes may also be used for heavier materials.

Hand welding with coated electrodes is still, of course, widely used, especially in positions other than downhand and where fit-up of the joint is not as good as that necessary for automatic welding processes or where complicated contours are welded. Thin materials up to around $^1/_2$ in. are often welded with an oxyacetylene torch, filler metal being melted under the flame tip. Oxyhydrogen is used for lower melting point metals.

For welding girth butt welds of pipe in high production applications, flash welding and oxyacetylene or induction-pressure welding are used. Inert arc welding, using consumable electrodes, is also widely used, particularly for non-ferrous welding.

Welding grooves for thin plate range from no groove (plates butted together) to various bevels of Vee grooves. The groove depends upon the welding process employed,

the backings and the penetration obtained with the specific process. For relatively thin material Vee grooves with about a 35 to 45 deg bevel (70 to 90 deg included angle) are quite common. For thicker plates the groove is usually a U or a modified Vee. It is necessary only that the groove be wide enough so that proper access can be obtained for welding and cleaning between passes. Grooves must be properly proportioned and "strongbacks," or other methods used to control distortion.

Many types of grooves other than the butt type are used. These may be lap joints using fillet welds, tee joints using fillet welds, edge joints using edge welds, plug welds, spot welds, seam welds, corner welds and others.

Magnetic particle, fluorescent penetrant, and oil powder testing may be used for inspection of most of these. Generally, however, it consists of visual inspection or, where pressure can be applied, soap tests or hydrostatic test. For pressure vessels and pipe service most of these inspection methods are applied—notably on nozzles and other attachments not lending themselves to radiographic examination. Leak detectors are also used where pressure or vacuum can be applied. This equipment is sensitive enough to detect a leak of 1 cu cm in 100 years.

Metallurgical Consideration

Service requirements of weldments and welding itself presents many problems in metallurgy.

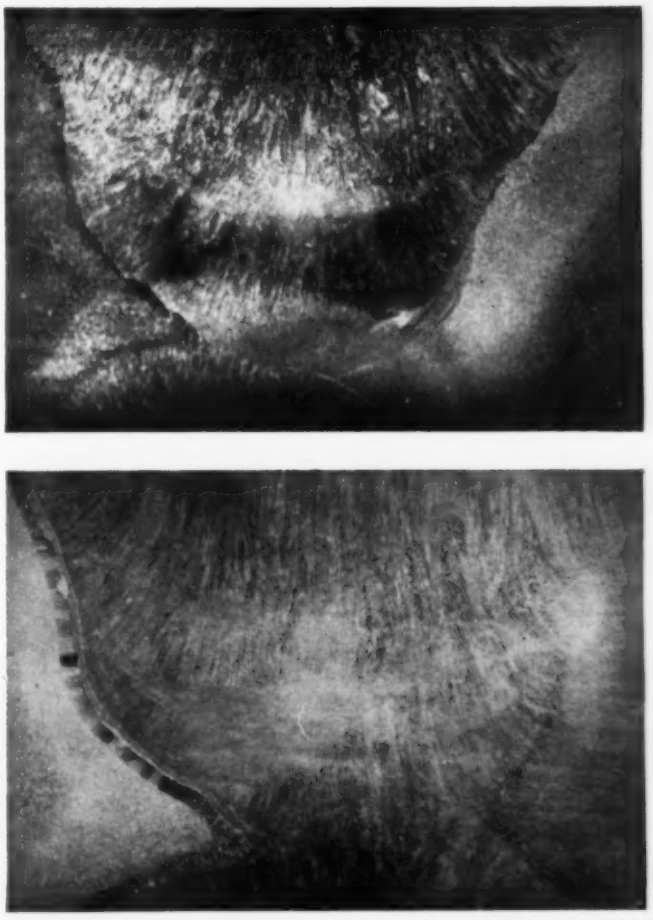
The service temperature is important in regulating the choice of materials. At high temperatures carbon steels oxidize or scale excessively and their strength drops rapidly at 650 F and above. Chromium added to the steel imparts oxidation resistance and molybdenum in small percentage increases high-temperature strength. There are, consequently, a series of steels containing $^1/_2$, 1, 2, 4, 9, 12, 15 per cent or higher amounts of chromium, each of which has increased resistance to oxidation or scaling. Most of these steels also are made with addition of $^1/_2$ to 1 per cent molybdenum to impart high-temperature strength. For highest resistance to oxidation and highest high-temperature strength the austenitic stainless steels are used. These contain 18 per cent chromium, or higher, and 8 per cent nickel, or higher.

The superheater tubing in boilers generally consists of a series of small-diameter tubes in the form of many loops suspended in the hot gas stream. The first passes of these loops are kept relatively cool by passage of low-temperature steam through them and subsequent passes are at higher temperatures as heat is transferred from the furnace gases through the tube walls to the steam. The first passes are usually made of carbon steel containing $^1/_2$ per cent molybdenum, the next ones of 1 $^1/_2$ per cent chromium steel with $^1/_2$ per cent molybdenum, the next containing 5 per cent chromium, $^1/_2$ per cent molybdenum titanium material and the last passes, which, in modern installations reach metal temperatures of around 1100F, are of 18 per cent chromium–8 per cent nickel steel stabilized with titanium. Of course, all the passes could employ stainless steel, but it is more economical and completely satisfactory to design to the limits of each material.

The various dissimilar materials must be joined together by welding and proper choice of welding procedures and heat treatments for stress relieving and imparting sufficient ductility to the joints must be chosen. Several metallurgical considerations enter into this. Special care must be taken where ferritic material is to be joined to austenitic material because of the large difference in thermal expansion of the two materials. Also where high temperature is involved (above about 800 F) carbon migration from the ferritic material to the austenitic material takes place.

Corrosive environment must be considered not only in choice of materials, but also in the choice of heat treatment of materials as heat treatment can make a material perform satisfactorily or unsatisfactorily.

Welds are subject to many types of defects, some of which are readily recognized, and others of which are found only by sad experience or by painstaking tests. Carbon steel welds are subject to defects known as "fisheyes," and others called "microfissures." Both are thought to be caused by hydrogen. The microfissures, as the name implies, can usually not be seen by the naked eye. They can be eliminated by choice of electrodes or by sufficient preheating. Stainless steel weld metal is also subject to microfissures of a different type. They can be eliminated by choice of a balanced weld metal analysis. The choice of procedures to eliminate this source of trouble might be termed a metallurgical consideration.



Upper view shows macro of carbon steel welded to stainless steel with stainless-steel weld metal as welded. Lower view is same weld after heat treatment at 1425 F for 24 hr.

The service must also be analyzed as regards temperature differences in the metal, which, in the case of thermal cycling or thermal shock, may set up stresses beyond the ability of the metal to withstand.

Facts and Figures

Some scientists now advance the theory that energy emanating from the sun is the result of nuclear reaction.

•

Bituminous Coal Institute reports that the Australian government is planning to de-socialize its coal industry.

•

With only one-sixteenth of the world's population, the United States produces over half the total electric power.

•

The maximum permissible dust concentration in nine large cities having smoke ordinances varies from 250 to 750 grains per cubic foot at 500 F.

•

Announcement was recently made concerning completion of several test flights of a naval helicopter powered by a 175-hp gas turbine.

•

What is probably Europe's oldest coal mine is at Kerkrade, near Heerlen in the Netherlands, where the monks in 1113 discovered what they called "flammable earth."

•

The Navy is reported to have made service tests of plastic pipe as a means of conserving copper. The result was so favorable, according to the *Defense Production Record*, that it has been decided to install such piping in several mine sweepers now being built.

•

The net heating value of dry natural gas varies widely, according to the district from which it comes. Some of the highest comes from West Virginia and the lowest from certain fields of Texas.

•

The first submarine nuclear-energy power plant, a land-based prototype of which is now well along, is reported as employing a fluid medium to extract heat from the reactor, together with a heat-exchanger to transfer heat from this medium to water for steam generation.

•

Coal reserves of the world, according to the U. S. Geological Survey, are distributed as follows: North America 43.2 per cent; Asia 40.6 per cent; Europe 11.5 per cent; Africa 3.7 per cent; South America 0.1 per cent; and Australasia 0.9 per cent.

•

The net station heat rate of Titus Station of Metropolitan Edison Company, Reading, Pa., for the year 1951, was 9661 Btu per kwhr and the availabilities of the two 80,000-kw boiler-turbine-generator units were 95.27 and 98.53 per cent. Steam conditions are 1475 psig, 1010 F at the superheater outlet with reheat to 1010 F.

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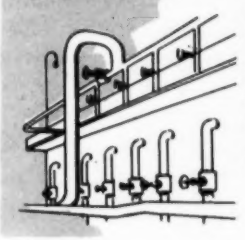

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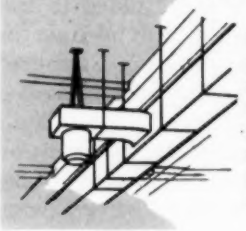

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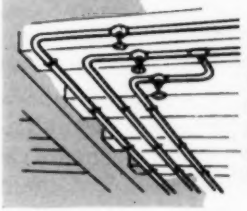

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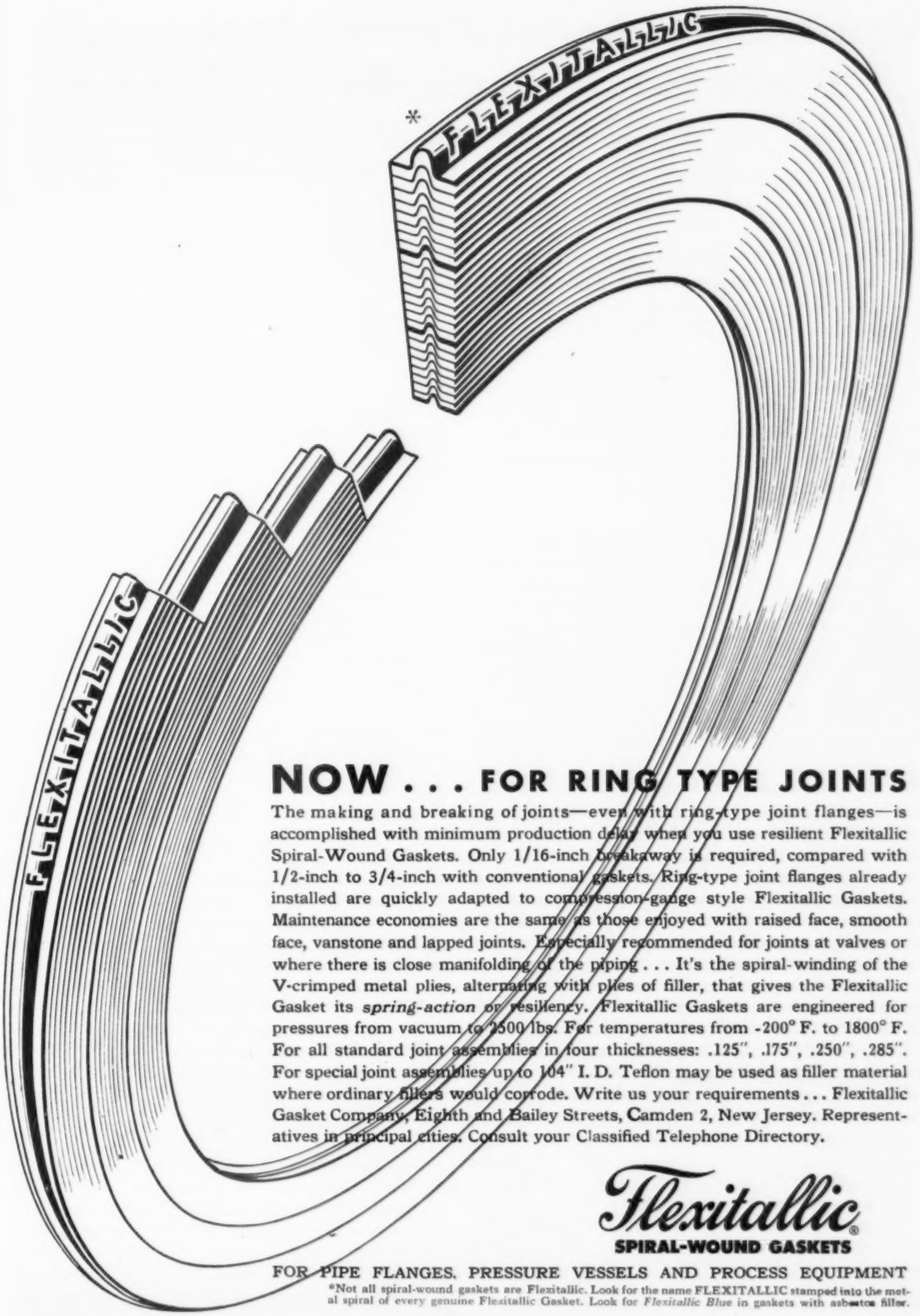

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Ignition Arches–A Proved Accessory for Bituminous Single-Retort Stokers

By T. S. SPICER, R. J. GRACE and C. C. WRIGHT
School of Mineral Industries, The Pennsylvania State College

Results of a series of comparative tests on duplicate boilers fired by single-retort underfeed stokers, one having a simple arch over the fuel bed and the other without an arch. The arch was found to permit higher burning rates; it resulted in increased efficiency; and, by eliminating the necessity for frequent attention to the fuel bed, it greatly reduced periodic smoke discharge.

THE single-retort stoker is recognized as an important member of the industrial bituminous coal burning equipment family. It has been marketed for over half a century and has performed faithfully under various combustion assignments, with a wide variety of coals. DeLorenzi[1] writes, "It is built in several models by different manufacturers, in sizes of 10 to 125 sq ft of grate area. It serves boilers ranging from 700 to 60,000 lb of steam per hour, and this capacity range includes more than 75 per cent of the number of commercial and industrial boilers installed in this country." Numerically, it exceeds all other stokers in installations.

Its simplicity and ease of operation make it a strong favorite in its field. The initial cost is low and the maintenance reasonable. It is well adapted for varying loads and can go from bank to high overload with ease and efficiency. The single-retort stoker is readily adaptable to conversion type installations and can be applied to most types of existing boilers. It gives better all around service with refractory furnaces than any other coal burner, and does not require fly-ash collectors.

Despite those inherent advantages, this type of stoker is being challenged more by competitive fuels than any other, as the result of a combination of factors. First, the small boiler plant uses this stoker almost exclusively and the ratio of man-hours per ton of coal is high compared to the larger plant. Thus the higher labor cost plus increased coal and freight rates has in some cases erased the economic advantage of using coal in the smaller plants where the single-retort stoker enjoyed its greatest popularity. Next, suitable stoker fuel has been scarce during the last decade and often commanded higher prices. The more plentiful inferior coals often resulted in more boiler room work and lower output. Recent pressure for smoke abatement has added to the problem because, when handling coals that require manual attention to the fuel bed, objectional smoke emissions are likely to occur.

[1] *Combustion Engineering* (1947).

Recognizing the problems involved and the threat to what was one of its major markets, the coal industry of Pennsylvania initiated a research program aimed at improving the performance of this class of stoker when burning Pennsylvania coals. The problem was assigned to the Coal Combustion Laboratory of the Mineral Industries Experiment Station[2] through a joint cooperative agreement between the Pennsylvania Bituminous Coal Industry and the Pennsylvania Department of Mines under the terms of a special legislative bill to foster new and improved uses of coal. Preliminary work was directed to analysis of performance with the various Pennsylvania coals using the time-lapse colored motion picture camera to observe the fuel bed under various conditions. A paper on this phase of the work, entitled "Some Factors Influencing the Performance of Single Retort Underfeed Stokers," was published in 1950.[3]

The principal deficiency of the single-retort stoker is the need for frequent manual attention to the bed in order to attain rated capacity when using certain available coals.

A major factor contributing to green fuel beds is the fine size consist of coals generally available. The modern water-wall boiler, which absorbs heat rather quickly, causes a lower firebox temperature and slow ignition, thus contributing to the black unreactive fuel bed over the center of the retort. Retarded ignition cuts down the burning rate and lowers the output.

Principle of Underfeed Combustion

In an underfeed stoker bed, the air and coal generally travel parallel to each other. Combustion occurs when the coal has reached the proper ignition temperature in the presence of oxygen. Ignition is only possible by the transfer of the heat down through the mass from the hot upper side and the passage of air (oxygen) upward through the coal mass. Thus the size consist of the fuel bed, with its inherent rate of heat transfer and permeability, and the firebox temperature are important factors.

The classic work of Nicholls[4] offers an explanation for the coking and non-coking condition of fuel beds in terms of rate of ignition and rate of burning. Ignition and the rate of ignition are defined as follows: "The fuel bed is considered to be ignited when it is heated to a temperature at which it would burn if oxygen or air were provided. And the rate of ignition is the rate at which the fuel bed is heated to this temperature." Coking and non-coking phenomenon are then defined substantially as follows: "(1) When the rate of ignition exceeds the rate

[2] Pennsylvania State College.
[3] By H. H. Baumann, T. S. Spicer and C. C. Wright, published in *Trans.* AIME, Feb. 1950.
[4] P. Nicholls, "Underfeed Combustion, Effect of Preheat and Distribution of Ash in Fuel Beds," U. S. Bureau of Mines Bulletin No. 378 (1934).

of burning, coking takes place, and the area between the rate of ignition curve and the rate of burning line is the coking area. (2) When the rate of burning equals the rate of ignition, no coking takes place."

Another principle involved and inherent in fuel beds is the "preoxidation" effect. Wright and Spicer[5] have demonstrated the effect of this principle on controlling coke formations in domestic underfeed stokers. Preliminary studies on industrial single-retort stokers at the Coal Combustion Laboratory disclosed, however, that "green" coal fuel beds were much more prevalent than those in which excessive coking or matting occurred.

Laboratory Approach

Many laborious and tedious experiments were conducted. These included application of the preoxidation principle, use of air baffles, introduction of high-pressure air into the center of the dormant fuel bed, use of ignition arches and a combination of the ignition arch and down air jet. Several types of tuyères were tested and a new design or retort and tuyère was used. One of the most promising of these was the refractory ignition arch which has contributed to the successful preformance of fuel burners for many years.

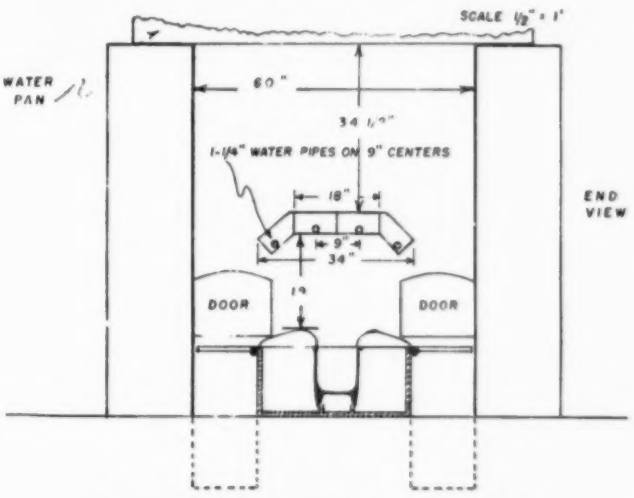


Fig. 1—Arch employed in preliminary test

The initial application of the arch to the brick setting of the 5 × 5-ft stoker with a water-baffle top used in preliminary test work, is shown in Fig. 1. Improved combustion was immediately noticed. Higher burning rates, less manual attention and better texture of fuel beds were also gained through the use of this device.

Design of the arch was subsequently changed from concave to flat and numerous design variations were tried involving width, height, type of cooling, checkered rather than solid, and combination arch and down-jet air introduction. Some of these are shown in Fig. 2. Tests of these variations indicated that the solid flat arch would give about as good results as any and also was much simpler.

The single-retort stoker used in these early investigations has a firebox area of 5 × 5 ft, with a nominal rating of 540 lb of coal per hour. General features of the stoker are shown in Fig. 3. Coal is delivered from the hopper to

[5] C. C. Wright and T. S. Spicer, "Control of Coke-Tree Formation in Domestic Underfeed Stokers," *Trans.* AIME (1942).

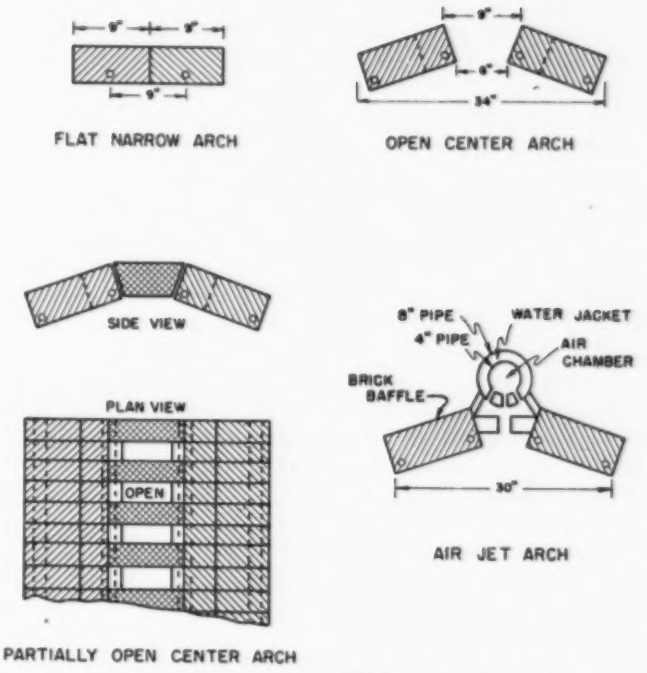


Fig. 2—Various arch modifications tried out

retort by means of a screw, and distribution along the retort is accomplished with a ram-type pusher, and the grate bars are the movable type in which every third bar moves while the pair between is fixed.

These qualifying tests were run with coals from most of the major Pennsylvania bituminous coal seams, and included fine slacks, nut and slack and nut sizes.

Although these early tests were gratifying, the authors felt that before they could offer recommendations for general distribution, the arches should be tested further in a conventional boiler, first for life and second for efficiency. A number of fuel engineers who had witnessed the early tests thought that the arch would not last very long under regular operating conditions; others believed it might detract from overall efficiency due to its shielding effect; still others wondered what effect it would have upon the metal parts of the stoker. Quantitative answers to the questions appeared essential before undertaking any large-scale plan for installation of arches. Therefore, a testing place where information could be secured, and the arch would be in daily use for long period of time, was sought and found at the Nittany Heating Plant, now adjacent to the new Coal Combustion Laboratory.

Description of Equipment

This heating plant has twin 178-hp fire-tube boilers, fired by twin 6 × 6-ft grate area stokers similar to the one shown in Fig. 3. The boilers are serviced by a 90-ft high

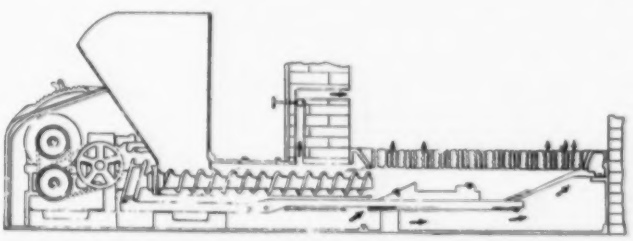


Fig. 3—Sectional elevation of experimental stoker

steel stack 48 in. in diameter. To offset draft deficiency, an induced-draft fan was installed for high rating tests, It is able to exhaust the gases from both units at maximum rating.

The boilers have calibrated water meters, automatic feedwater devices and low-water cut-offs, and a recording stack temperature-CO_2 meter, which takes a continuous record during test. There are indicating draft gages, steam pressure gages, an automatic steam pressure regulator, integrating clocks recording the total operating time, and indicating thermometers at several points. A photograph of the twin-stoker boiler set-up is shown in Fig. 4.

A flat arch was installed in one of these boilers as shown diagrammatically in Fig. 5, while the other boiler was unchanged to serve as a control. This arch was installed in the summer of 1948 and, except for an occasional shutdown, has been in continual service ever since.

Tests

Comparative tests were run on both the arch-equipped and the non-arched boiler, in order (1) to measure the relative maximum burning rate; (2) to observe the relative efficiencies of the boilers; (3) to study the stoker performance between dump periods without manual attention of the bed; and (4) to observe the relative amount of smoke, fly-ash carryover, degree of clinker formation, etc.

Fig. 4—View of twin stoker-fired units

The tests were run in pairs, one with the arch-equipped stoker boiler unit, the other with the standard unit. The first group to be discussed will be the natural-draft tests, the second, the group with induced-draft. Table 1 and Fig. 7, respectively, show the proximate and screen analyses of the test coals. Table 2 is a condensed summary of operating data for the tests reported.

TABLE 1

ANALYSES OF COALS TESTED ("As fired" Basis)

Test No.	1 & 2	3 & 4	5 & 6	7 & 8	9 & 10	11 & 12	13 & 14	15 & 16
Coal	A	B	C	D	E	F	G	H
Seam	Pgh.	(1)	Pgh.	(1)	Lower Kittan.	(2)	Upper Prprt.	Pgh.
Size	2"x0	Run of Mine	2"x0	Run of Mine	3/4"x0	Run of Mine	2"x0	2"x0
Proximate Analyses %								
H_2O	6.8	4.4	2.8	7.3	1.3	5.3	2.5	2.0
V.M.	35.4	22.7	36.2	21.3	22.3	23.0	30.1	36.1
F.C.	48.9	61.3	51.4	61.6	67.3	62.3	59.2	53.2
Ash	8.9	11.6	9.6	9.8	9.1	9.4	8.2	8.7
Sulfur %	2.0	1.4	2.1	1.1	2.3	1.1	1.2	1.6
B.t.u./lb.	12,660	12,780	13,035	12,760	14,050	13,115	14,070	13,380
A.S.T.°F	2,210	2,510	2,250	2,470	2,350			2,380

(1) Regular plant coal, sold under designation of "Miller B Seam," actual seam unknown. Large lumps crushed to approximately 2" during operation.

(2) Coal from local source, same general charactoristics as (1). Selected because of its abnormally large size consist.

TABLE 2

Condensed Summary of Operating Data

TEST No.	1 N.D.	2 N.D.	3 N.D.	4 N.D.	5* N.D.	6 N.D.	7 I.D.	8 I.D.	9 I.D.	10 I.D.	11 I.D.	12 I.D.	13 I.D.	14 I.D.	15 I.D.	16 I.D.
Boiler	Arch	Std.	Arch	Std.	Arch	Std.	Arch	Std.	Arch	Std.	Arch	Std.	Arch	Std.	Arch	Std.
Coal	A	A	B	B	C	C	D	D*	E	E	F	F	G	G	H	H
1. Efficiency, %	74.7	71.0	73.8	69.2	74.8	74.3	72.7	73.2	72.0	71.6	69.3	70.4	69.4	70.2	78.1	74.0
2. Steam pressure, Av. psig.	8.5	7.8	11.2	5.6	7.7	12.1	9.8	9.5	8.3	8.8	10.4	8.6	10.3	10.4	10.3	10.5
3. Feed water temperature, Av. °F	111	112	111	89	118	121	128	120	123	117	111	119	116	94	104	87
4. Gas temp., leaving boiler Av. °F	397	396	375	386	402	388	410	390	383	376	444	415	445	420	456	457
5. CO_2% (average "on" & "off")	7.0	6.2	7.1	6.5	8.4	7.7	8.7	6.0	5.2	5.0	6.3	5.6	7.1	7.2	9.1	8.6
6. Fuel heating value "as fired", Btu/lb.	12,660	12,730	12,700	12,780	13,035	13,035	13,200	12,760	14,050	14,050	13,055	13,115	14,170	14,070	13,230	13,380
7. Refuse, dry % ash	77.0	74.2	78.4	82.5	79.2	75.4	75.9	77.1	59.4	53.4	61.1	65.9	58.7	54.4	74.9	79.2
8. Equiv. evap. av. # steam/# "as fired" coal	9.70	9.30	9.44	9.09	10.10	9.98	9.89	9.62	10.43	10.36	9.32	9.51	10.14	10.18	10.65	10.20
9. Av. burning rate (incl. "off" periods) #/hr.	489	355	439	485	522	523	705	632	530	430	691	543	735	621	954	855
10. Stoker operation, ("on" periods) % of time, blower	81.3	78.4	94.2	92.0	97.4	97.7	95.6	94.5	94.4	95.8	95.4	96.8	96.7	94.1	94.8	91.0
feed	69.8	75.4	78.9	90.2	90.4	90.0	85.4	85.4	84.9	86.4	84.8	87.5	89.0	81.3	87.2	87.6
11. Actual feed rate lbs./hr.	671	470	556	516	577	581	826	741	623	498	815	621	825	784	1094	977
12. Excess air %(av. of "on" and "off" periods)	160	192	148	183	112	129	172	178	242	253	177	216	142	137	98	106
13. Equiv. evap., av. lbs./hr.	4,568	3,305	4,230	4,236	5,246	5,223	6,972	6,084	5,526	4,455	6,442	5,163	7,447	6,324	10,158	8,724
14. Equiv. evap. rating of unit, lbs./hr.	6,160	6,160	6,160	6,160	6,160	6,160	6,160	6,160	6,160	6,160	6,160	6,160	6,160	6,160	6,160	6,160
15. Equiv. evap. (maximum for one hour) lbs./hr.	6,405	4,565	5,640	5,150	6,076	5,836	8,106	7,560	6,084	6,028	7,395	6,304	9,071	8,112	11,959	10,338
16. No. of times fire was manually attended#	8	15	3	26	0	0	0	1	0	0	0	1	4	4	0	0
17. Approximate total minutes of manual attention#	9	45	6	52	0	0	0	1	0	0	0	1	5	6	0	0
18. No. of times refuse was dumped	5	5	3	3	3	3	3	3	3	3	2	3	2	2	2	2
19. Duration of test, hrs.	24**	24**	16	16	16	16	12	12	12.0	12.0	8*	12	10	8**	10	10

N.D. - Natural draft
I.D. - Induced draft

Excluding burndown and dumps
* Last 4 hours omitted because of power failure during 9th hour
** First 2 hours omitted because insufficient coal fed before test to insure bed of test coal

Natural-Draft Test

Test 1 & 2 (Coal A)—These tests of 24-hr duration were run with the Pittsburgh seam coal, 2 in. × 0 size. They were conducted in such a manner as to retain the regular operating features, with the stokers running in response to load demand. The stoker under test was adjusted to give maximum burning rate under load conditions, but with a minimum of manual attention. This accounts for the slight difference in operating time for the two tests. They were run as close to consecutive days as possible, so that the draft existing at that time of the year would be the same.

The calorific value of the coal varied slightly from Test 1 to Test 2, due to change in moisture content. The fires were cleaned when the fireman deemed necessary. The persistent decline of CO_2 content of the stack gases was a reliable indication that the accumulated ash on the grates was interfering with normal combustion. The ash-softening temperature of this coal was 2210 F; thus if the fires were not cleaned frequently, a bad clinker on the dump grates would result. Immediately after cleaning the fires, the CO_2 always showed a sharp rise. In part this marked increase was due to the workings of the bed that accompanies the cleaning. Although the total coal consumption was higher during the tests on the arch unit (Test 1), yet both were cleaned five times during the 24-hr period. No steam was vented to the atmosphere during these tests.

While the feed rate of the non-arch unit was 470 lb per hr, as compared to 671 lb per hr for the arch-equipped unit, yet the stack temperatures were practically the same, 397 F and 396 F. These stack temperatures are an integrated average of the "on and off" periods for a full 24-hr test. The integrated average CO_2 for the on-off periods was 7.0 per cent for the arch unit as compared to 6.2 per cent for the non-arch unit.

Since it is normal for the CO_2 to be higher during the "on" periods, and as the per cent "on" time was 6 per cent less for the arch unit, the comparative "on-time" CO_2 values for the arch and non-arch boilers were more favorable in the arch boiler than the average results indicate. In Test 1 the stoker of the arch boiler operated 69.8 per cent of the time, compared to 75.4 per cent of the time for the one without the arch.

The overall efficiency of the arch unit was 74.7 per cent as compared to 71 per cent for the regular unit. The former includes 1.3 per cent in the form of feedwater heating, as a result of returning the cooling water from the arch supports to the return sump from which the feed water is drawn.

The arch unit bed was attended six times, excluding the attention normally necessary in preparing the beds for dumping of ashes, against fifteen times for the unit without the arch. The time for manual attention was 9 min for the arch unit in 24 hr, against 45 min for the other.

The overall average burning rates for the 24 hr, including the off-time, were 468.8 lb per hr for the arch unit against 354.5 lb per hr for the standard. The feed rate of 671 lb per hr for the arch against 470 lb per hr for the main unit is a more significant figure, because of the intermittent operation.

Tests 3 & 4 (Coal B)—The object of these tests was to compare the performance of the two units when both stokers were run at essentially the same feed rates. The tests were continuous ones of 16-hr duration. The feed rate was adjusted on the standard unit to give maximum burning rate, and then duplicated on the arch unit. One distinct difference, however, was that the bed on the arched unit was worked only occasionally as required, while on the non-arch unit, the bed was worked every half hour, as it was hardly possible to keep it burning unless this was done. This coal was from regular plant shipment,very fine, slightly moist, and difficult to handle.

The arch unit was attended three times for a total of 6 min excluding the manual attention required for the three dumping periods, against twenty-six times for the non-arch unit for a total of 52 min. The essential difference in the working between the two units was that with the arch, occasionally a blow hole would have to be filled in, while with the other unit, the bed had to be vigorously stirred to promote ignition. This test actually represented regular operation very closely. It showed a difference in efficiency of 4.8 per cent, in favor of the arch which amounts to a fuel reduction of 6.9 per cent. Using these figures on what might be expected as regular plant performance, with the amount of coal that was estimated as burned under the arch, calculations indicated a saving of about $500 per year of arch unit operation.

The overall average burning rate was 439 lb per hr for the arch unit, as compared to 465 lb for the standard.

Tests 5 & 6 (Coal C)—These were continuous 16-hr tests, with no manual attention other than that required for dumping. The coal for these tests was Pittsburgh 2 in. × 0, which was a little coarser than the average and had been on hand about 8 months. Both units were run at the same rate, which was established by the maximum possible with the non-arch unit. Although the calculated efficiencies were about the same, it is believed that the results for the arch unit might be one or two per cent higher had both units been given the usual treatment.

Induced-Draft Tests

In order to study the comparative performance at the higher ratings, the stoker fan was adjusted with damper wide open, and the induced draft was adjusted by means of dampers to give about 0.08-in. H_2O over-fire draft. The coal feed was then established to give equilibrium conditions. Tests were shortened from 16 to 12 hr. The duration of these tests was much longer than generally run on ASME code acceptance tests.

Tests 7 & 8 (Coal D)—These were continuous 12-hr tests with no manual attention given to the bed other than that required for dumping. The coal used was regular plant shipment, but from a different supplier than that used in tests 3 and 4. An effort was made to keep the coal uniform for both tests, but unfortunately the coal for the non-arch unit was noticeably coarser than that used in the arch unit. As size consist is one of the major factors in burning performance, this did affect the relative operation. The summary data of Table 2 show that the average burning rate for the arch unit was only 17 per cent higher than for the non-arch unit over the 12-hr test period. However, the data of Table 3 for individual 4-hr periods show that the bed of the non-arch unit became progressively poorer while that of the arch unit remained essentially constant. During the last 4-hr period, between dumps, the non-arch unit was burning 35 per cent less than the arched unit. The arch boiler operated at 113 per cent of normal boiler rating with this coal.

Tests 9 & 10 (Coal E)—This was a 12-hr continuous test without manual attention using $^3/_4$ in. × 0 slack coal from the Lower Kittanning Seam. Due to extreme fineness this coal was probably the most difficult to burn. The arch unit burned 23.2 per cent more coal than the non-arch one. However, the fuel bed of the latter became progressively worse, and during the last 4 hr the arch unit was burning 104 per cent more coal. This shows that starting with a clean and a well conditioned fire, especially with a poor coal, the fuel bed may last for a while, but eventually it thickens and loses ignition, until there is no comparison to the original operation. This is one coal which should have occasional working even with the arch to fill in an occasional blowhole and to improve the distribution.

At a later date this coal was again run under the arch after the coal had been tempered with water to give a surface moisture content of 5 per cent. The performance indicated that this resulted in better fuel bed conditions, but the coal could not be fed properly.

Tests 11 & 12 (Coal F)—These tests were run for 12 hr continuously with three 4-hr periods. The beds were burned down for 30 min before dumping. They were not supposed to be manually attended, but with the bed without the arch, a blowhole developed which was so severe it had to be filled in. The data show that the arch unit ran at 27.3 per cent higher rating, including the burn-down periods, while the relative feed rates were 815 and 621 lb per hr, respectively.

Tests 13 & 14 (Coal G)—This coal from the upper Freeport Seam was very fine (65 per cent, $^1/_8$ in. × 0). It was a medium volatile coal, and has favorable properties for making metallurgical coke. Because the quality of the refuse depends upon how long the bed is burned down, it was decided to try a 10-hr continuous operation with two 5-hr periods, and heavier beds to eliminate blowholes. This necessitated a slight increase in the length of the burn-down periods. The average burning rate was 735 lb per hr for the arch unit, or 18.4 per cent higher than the 621 lb per hr burning rate for the non-arch unit. With the arch it was possible to average 120.9 per cent rating of the boiler, and for one hour it operated at 147.3 per cent rating.

TABLE 3

COMPARISON OF AVERAGE HOURLY BURNING RATES (4-hour period)

Periods	No. 1 Unit (Arch)	No. 2 Unit (Non-Arch)	Increase In Burning Rate With Arch Unit
	Plant Coal (B-Seam) (1¼" X 0)		
	Test No. 7	Test No. 8	
0-4 hr.	699 lbs/hr	758 lbs/hr	
4-8 hr.	735 "	631 "	
8-12 hr.	684 "	507 "	35.0%
Test Average	706 "	632 "	17.0%
	Lower Kittanning Seam (3/4" X 0)		
	Test No. 9	Test No. 10	
0-4 hr.	450 lbs/hr	550 lbs/hr	
4-8 hr.	569 "	460 "	
8-12 hr.	572 "	280 "	104%
Test Average	530 "	430 "	23.2%

Tests 15 & 16 (Coal H)—The 2 in. × 0 coal used in these tests was obtained from the Pittsburgh Seam, but from a different mine than the Pittsburgh Seam test coal previously used. The tests were run for 10 hr continuously with no manual attention and showed the highest rating obtained with these units, the arch unit showing 11.6 per cent higher than the non-arch unit. When one considers that this coal is specified by the manufacturer, as the ideal, both in size consist and seam, for use on this stoker, a fair idea is obtained of what can be expected in the way of performance.

Arch Design And Construction

The primary purpose of the use of an arch or refractory baffle above a fuel bed is to heat the fuel underneath. The

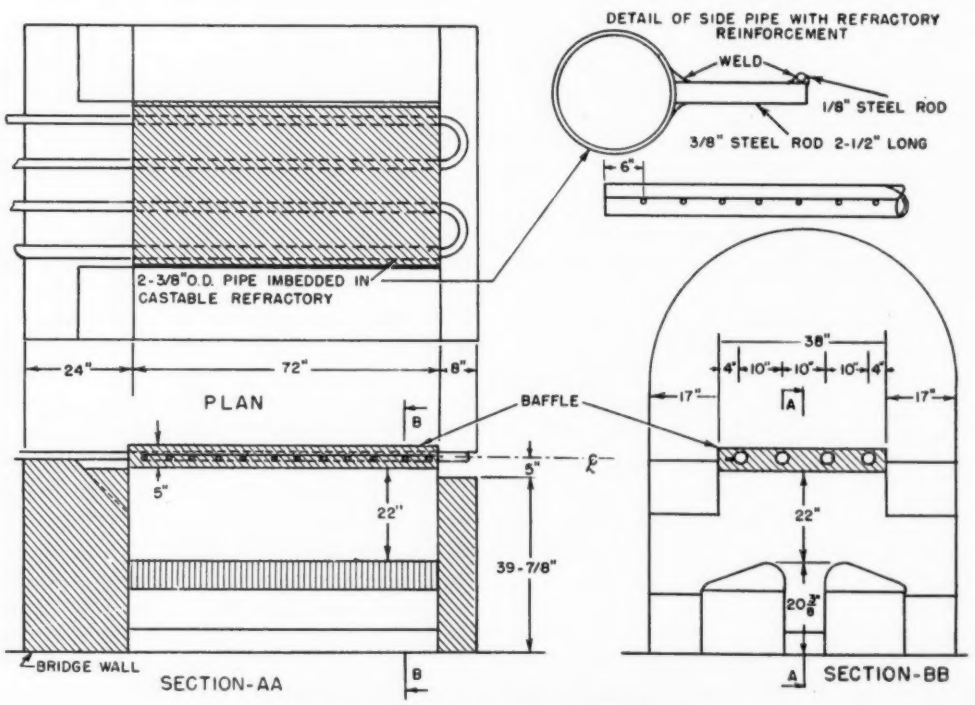


Fig. 5—Arch for 6 × 6-ft Skelly stoker

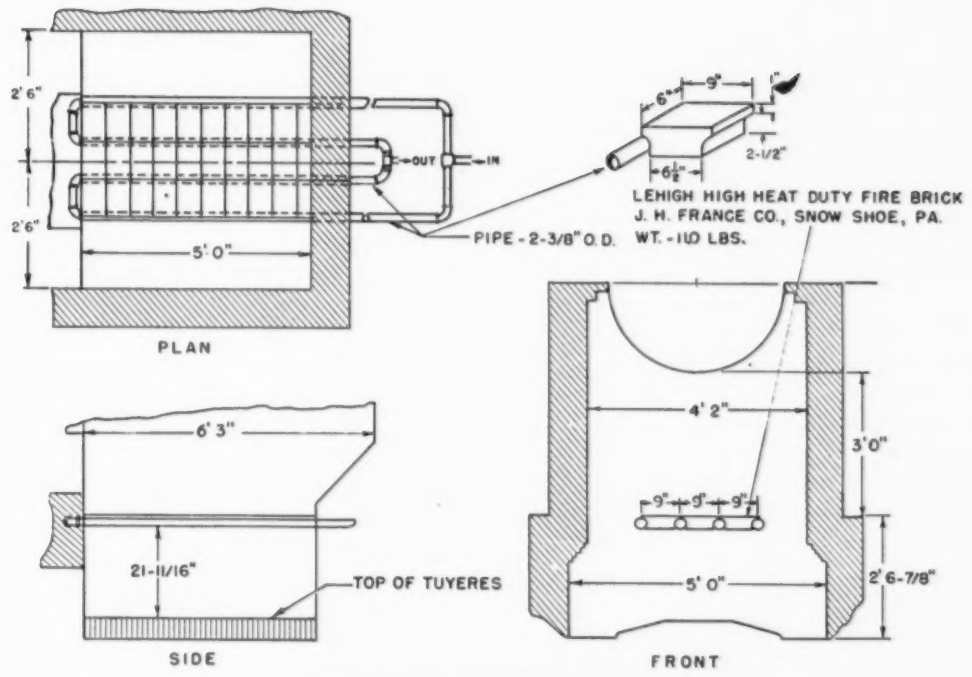


Fig. 6—Arch for 5 × 5-ft Skelly stoker

rate of ignition is thereby increased, thus favoring better equilibrium conditions between the rate of ignition and the rate of combustion The effectiveness of the arch depends upon (1) its temperature; (2) the amount of heat collected by the arch; and (3) the amount of reflected heat which reaches the bed. The temperature will depend upon the kind of fuel used and the height of the arch above the bed. The heat collected by the arch depends upon the shape and the nature of the refractory. The length of flame also affects the arch temperature. The radiation effect of the arch upon green coal depends upon the distance, and varies according to the law of the inverse squares.

The arch installed over the 6 × 6-ft stoker and used for the comparative tests was of flat design. It was 38 in. wide and 5 in. thick, running the full length of the firebox. The underside was 22 in. from the top of the fire-bars. The 38 in. width represents 53 per cent of the firebox cross-section. The highest rating possible with the natural draft stack was 750 lb per hr. for the 6-hr period with one boiler on the line. This is equivalent to 21 lb per ft per hr. With induced draft, the highest rate obtained to date, averaged for a 10-hr period including the off-periods for burning down and dumping, is equivalent to 26.5 lb per sq ft per hr. This arch is constructed from a castable material having a service rating of 2700 F. The softening point is 2920 F. The arch is supported by 2-in. pipes, spaced on 10-in. centers. Water from the feed-water sump is circulated by means of a $^1/_4$-hp motor-driven domestic hot-water circulator at a rate of approximately 11 gal per min. The water temperature rise across the arch is about 10 to 15 deg F. depending upon the intensity of the fire, and also the temperature of the water entering the arch pipe. No effort is made to cool the arch refractory, but only to cool the supporting members so that they will be structurally strong enough to support the refractory. The pipes were given a light coating of paraffin before the castable refractory was poured.

Fig. 5 shows a reinforced edge of the 4-in. arch extension over the last supporting pipe. Originally there was no supporting or reinforcing iron used. However, after about $2^1/_2$ years of service, the edges cracked because of jarring given by the firemen during the cleaning periods. This reinforced construction along the edges of the arch appears to be superior to the original design.

There are two important arch dimensions, namely, the width of arch and its height above the grate bed. In general the height can be determined by the depth of level plus 15 to 18 in. depending upon the firing rate. The width can be established as about 50 per cent of the furnace cross-section, but varies to some extent by the radiation effect required by the coal.

An arch was installed over a 5 × 5-ft stoker, which fires a 70 hp two-pass fire-tube boiler having a refractory firebox. Details of this arch are shown in Fig. 6. The underside of the arch is $21^1/_2$ in. from the top of the fire-bars and the overall width of the arch, including the pipes, is approximately 30 in., which is about 60 per cent of the width of the firebox at the point of installation. The bricks used are somewhat similar to the design employed by the railroads, and leave the supporting pipe exposed. The thickness of the brick is $3^1/_2$ in. and it has a melting point of 3100 F. When this design is used, supporting pipes should be connected to the circulation of the boiler water, as practiced by the railroads. These exposed pipes absorb heat equivalent to about 10 per cent of the rating of the boiler. By using this design, the refractory cost of the arch, even including the pattern charge for one particular job, was cut in half. Experimental investigations are still underway with this arch.

Cooling the Supporting Pipes

The problem of cooling the supporting members of the arch can be solved in a number of ways: (1) The boiler feedwater may be circulated through the arch to a common sump; (2) tap-water, if available at a sufficiently cheap rate, may be run through the pipe to cool it. The mineral content of raw water may eventually cause a lime build-up on the inside of the pipes, but it is believed

by some engineers that this will not be a serious matter. A disadvantage of using water that is wasted is that one to two per cent of the boiler rating may be lost in this manner with covered pipes, and with exposed supporting pipes the loss may exceed 10 per cent. When using the feedwater the heat is returned to the boiler and is not lost. (3) The most practical solution is, as the railroads are doing, to connect it with the main circulation of the boiler. This will then yield a higher efficiency due to the extra heat absorption surface available.

Cost of Arch Installation

The cost of installing an arch will naturally depend upon the size and conditions. The college heating plant installation was made at an approximate cost of $200, including the water-circulator, pipe, refractory and labor. The cost of the castable material alone was about $50. Use of the prefired arch brick may reduce the refractory costs to about a half.

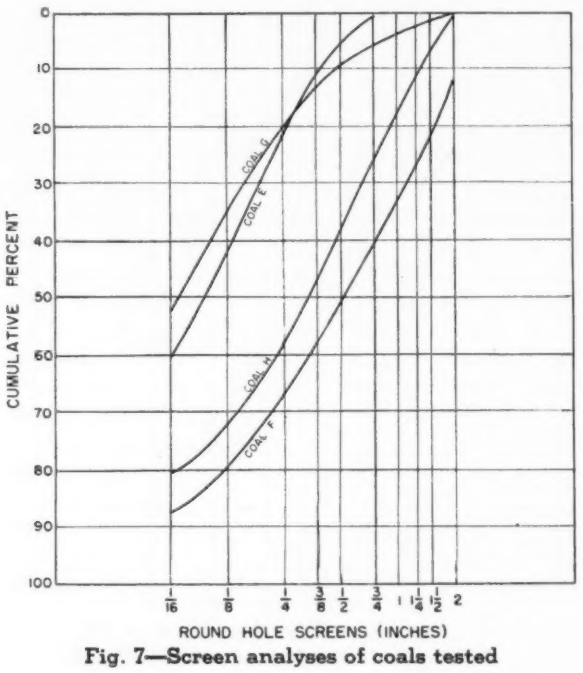


Fig. 7—Screen analyses of coals tested

The arch used in the tests herein described, has completed almost three years of continual service. At the end of about $2^1/_2$ yr, the 4-in. edges overhanging the supporting pipes had to be replaced. The new design appears to eliminate this weakness.

Operating Observations

In addition to the items pointed out under the discussion of the tests, other interesting points are worth mentioning. There seem to be no indications that the arch has increased the maintenance on the stoker. The records to date actually show lower yearly maintenance on the arch stoker than on the non-arch unit despite the fact that the former has burned substantially more coal. This may be merely coincidental, and no definite claims are made at this time.

The refractory firebox, which on the 6 × 6-ft stoker extends from the dump grate up to the arch, did not seem to be in any poorer shape or any different condition than in the unit which did not have the arch. When one considers that the stoker with the arch operated at a higher rating and burned at least 50 per cent more coal over the same period than did the non-arch unit, this would suggest a decided advantage in favor of the arch unit.

Trouble from clinker formation did not seem to be materially different for the two units although in some cases large clinkers did form next to the wall. This was probably due to the very high ratings under which the stokers were operated. Clinkers have also formed occasionally in both stokers, near the center of the bridgewall, just back of the rear end of the retort.

There is definite improvement during the banking period, as the arch tends to keep the fire hotter and alive, and thus a quicker response is one of the positive improvements which has been observed through actual operation, and not merely test operation.

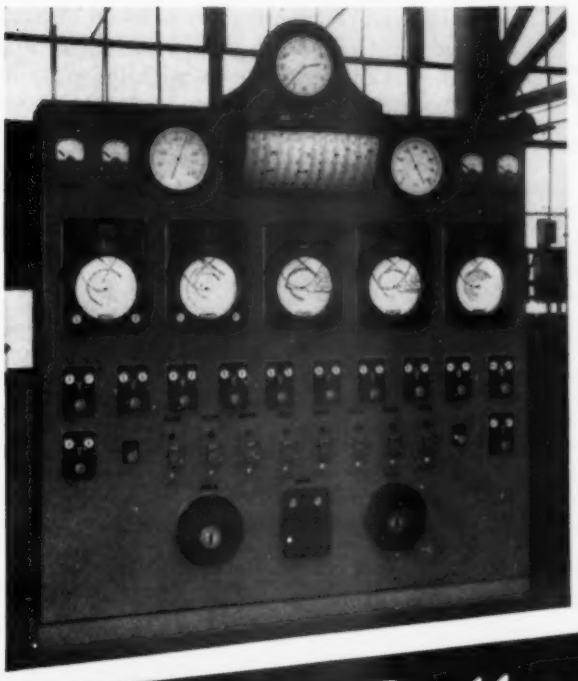
One of the most surprising incidents of regular operation occurred when a load of badly oxidized strip coal was received. The stoker without the arch could not burn it at all, as it drifted into the dump grates, while in the arch boiler the coal burned at a tremendously high rate.

The arch has definitely eliminated much of the smoke due to manual stirring, although smoke will occur under the arch if the bed is stirred. Occasionally, it is necessary to fill in a blowhole or distribute the coal due to uneven distribution. In most cases this manual attention has been reduced to about a 2-min chop-in action, once every couple of hours and need result in very little smoke production. The beds still have to be manually attended during the burn-down and dump-period.

It has been impossible to measure accurately the amount of fly ash that is carried over into the tubes and to the stack in these twin units.

Conclusions

1. Use of the ignition arch as an accessory for the single-retort stoker has proved to be a practical, inexpensive and beneficial device. After three years of service on one arched unit, the arch is still in good condition and offers promise of years of additional service.
2. Increased burning rates can be expected and the degree of improvement will depend upon the rating of stoker, and the size and characteristics of the coal. With the coals tested, it varied from 11.1 per cent on the most ideal coal to 32.1 percent on the poorer coals. The average increase in feed rate varied from 15.0 per cent to 42.7 per cent. The burn down and fire cleaning period accounts for the difference between burning and feeding rates.
3. Combustion of coal under the arch remained rather uniform throughout the tests while the bed without the arch required considerable manual attention.
4. To gain maximum benefit from an arch with most coals, the fire should be kept uniformly thin. The uneven bed thickness in the tests reported meant that the bed had to be too heavy on one side in order to carry minimum depth on the light side.
5. Higher boiler efficiency is another benefit of the arch.
6. The unreactive fuel bed over the retort section is eliminated by the arch.
7. The arch permits a definite reduction of manual attention to fires.
8. The periodic smoke discharge, resulting from disturbing the bed, is substantially reduced because there is less disturbance.
9. Fly-ash carryover is less with the arch.



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Estimating Low Amounts of Silica in Water in the Field Using a Slide Comparator

By George J. Crits

Cochrane Corp., Philadelphia, Penna.

The absence of photoelectric colorimeters in many small laboratories and power stations makes difficult the analysis of low amounts of silica in condensates, demineralizer and boiler feed waters. The widely employed Taylor Water Analyzer[1] cannot be used for evaluating silica below 2.0 ppm with the standard silica-yellow slide. However, by using this analyzer with the "High Phosphate Slide"[2] and with the molybdate-sulfite-amino acid reagents[3] silica may be estimated in the range of 0–2 ppm. The "phosphate-blue" color does not exactly match the purple or grayish cast characteristics of the "silica-blue" but comparison of shades has been found quite adequate with the analysis obtained within ± 0.2 ppm SiO_2. The use of standard silica solutions to familiarize oneself with these colors is recommended.

The following solutions are required and should be prepared freshly every three weeks. They should be stored in plastic or hard rubber bottles.

Solution A—75 g ammonia molybdate, $(NH_4)_6Mo_7O_{24}\cdot 4H_2O$. 93 ml of concentrated H_2SO_4. Make up to one liter with silica-free distilled or condensate water.

Solution B—0.5 g amino-2-naphthol-4-sulfonic acid, Eastman organic chemicals No. 360. 30 g sodium bisulfite, $NaHSO_3$. 1 g sodium sulfite, Na_2SO_3. Make up to 200 cu cm with silica-free distilled or condensate water.

NOTE: Solution A may be substituted by the solutions used in the standard high-silica test where HCl and ammonia molybdate are contained; however, the total quantities to be employed should be limited to 3 cu cm additions per 50 cu cm water to be tested.

Outline of Procedure

1. To a sample of 50 cu cm water to be tested, add 3 cu cm of Solution A.
2. Wait exactly 5 minutes.
3. Add 2 cu cm of Solution B.
4. Shake, wait $1\frac{1}{2}$ minutes, and pour into the center Nessler tube (150 mm depth) of the Taylor Water Analyzer.
5. Match depth of color or shade with the "High Phosphate" slide (0–100) ordinarily used with the Model T-O slide comparator.
6. Obtain silica value by referring to the table below.

If phosphates are known to be present, add 1 cu cm 10 per cent oxalic acid just before step 3.

CAUTION—All glassware, equipment and pipettes must be carefully rinsed with distilled water or silica-free water so that the test water or reagents be not contaminated. In the field or laboratories where no silica-free water is available, it is suggested that the following technique be applied.

(*a*) Rinse sample water measuring graduate or volumetric flask with *the water to be tested.*

(*b*) Rinse the flask, in which the test is to be performed, with *the water to be tested.*

(*c*) Instead of pipettes use a 10 cu cm graduate for measuring out the solution A and B mentioned above. Rinse the 10 cu cm graduate with *the water to be tested.* Throw away and do not pour back into reagent bottles any excess solution that may have been overdrawn. To do so may mean contamination of reagents with silica.

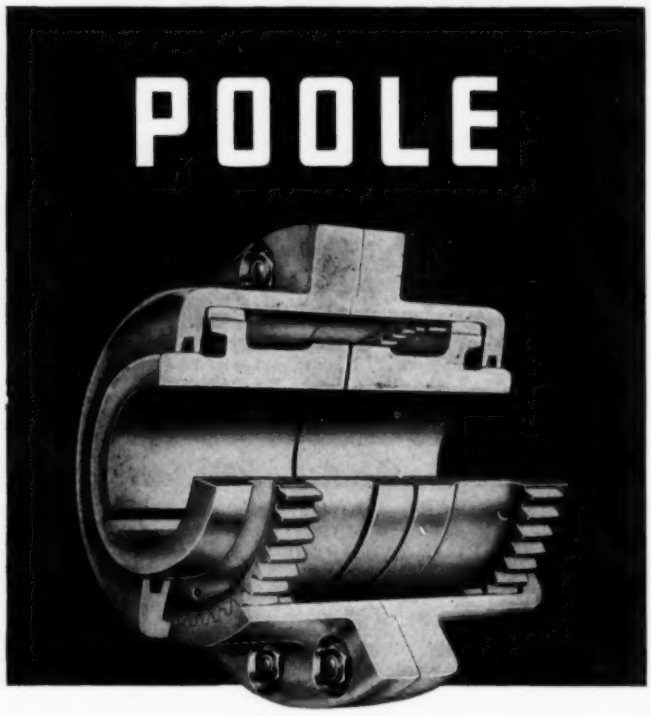
(*d*) Rinse Nessler tube with *the water to be tested.*

PHOSPHATE SLIDE READINGS EQUIVALENT TO SILICA

High Phosphate Slide Reading	Approximate Silica Ppm $SiO_2 \pm 0.2$
0	0
5	0.2
10	0.3
20	0.5
30	0.7
40	0.9
50	1.1
60	1.5
70	1.9

[1, 2] Both of these pieces of equipment are generally found in small laboratories and power stations. W. A. Taylor & Company, 7300 York Road, Baltimore 4, Md., are suppliers.

[3] Bunting, W. E., *Ind. Eng. Chem., Anal. Ed.*, **16**, 612–615 (1944).



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Instrumentation Conference

A REGIONAL conference on "Power Plant Instrumentation" sponsored by the New York section of the Instrument Society of America was held at the Statler Hotel, New York City, on February 7–8.

Three engineers from the American Gas & Electric Service Corporation, **T. T. Frankenberg, C. P. Lugrin** and **R. P. Marche,** prepared a paper entitled "Some Considerations in the Determination of Excess Air." As the ratio of heat absorbed to generate steam to the total heat released in the furnace decreases, excess air values become more critical and the range of acceptable values of CO_2 narrows. Metering of air flow for modern boilers is complicated by the increasing complexity of the air-gas path, which may include recirculation for steam temperature control, pulverizer, primary-air and tempering-air circuits, air heater bypass and the air system for the pulverizers. Because of these complexities of air-flow measurement, the direct measurement of excess air deserves attention. If the amount of oxygen in the flue gas is determined, this measurement can be applied to readjust the combustion control and steam temperature control systems. One advantage of the oxygen analyzer is that it is naturally a vernier type of reading. As an operating guide oxygen measurement is quite satisfactory because it shows substantial change with variation in excess air. The authors were of the belief that the oxygen analyzer will be used more widely with large modern boilers and expressed the hope that manufacturers of this type of instrument would direct continued effort to improve reliability, reduce maintenance costs and develop more flexible sampling systems.

"Instrumentation for Power Plant Water Treatment" was the subject of a paper by **V. J. Feeney** of Burns and Roe, Inc. He described the design of the water-treatment system for the Greenwich Station of Atlantic City Electric Company, which is to supply approximately 400,000 lb of process steam per hour to a synthetic fiber plant of E. I. du Pont de Nemours & Co. located near Gibbstown, N. J. Raw water for the station which will require nearly 100 per cent makeup will be obtained from the Delaware River and pumped to three 600,000-gal tanks. It is delivered to a mechanically agitated mixing tank and then to two upflow sludge-blanket type precipitators, following which the clarified effluent passes through gravity filters to a concrete clearwell. Filtered water then is pumped to two batteries of ion exchange units operating on the sodium and hydrogen cycles. The effluents from these exchangers are blended to produce a final alkalinity of 5 to 10 ppm and pass through a degasifier to a treated-water clearwell from which makeup water is supplied to the boiler plant. The author enumerated the specific types of control equipment installed at each point in the cycle.

T. R. Hardin of the Hartford Steam Boiler Inspection and Insurance Company presented a paper entitled "Maintenance of Instruments, Controls and Safety Devices for the Safe Operation of Power Boilers" in which he repeatedly emphasized the importance of proper maintenance if accidents and outages are to be prevented.

One of the principal causes of boiler accidents is overheating due to the accumulation of deposits or the introduction of foreign materials through feedwater. Where raw water is independently treated and introduced to boilers without passing through evaporators, the failure of an automatic device or instrument to control the water-treating cycle may result in the deposition of scale-forming materials in a boiler. Conductivity meters are used to check purity of steam in some plants, and their failure may cause carryover of materials which deposit in superheaters.

Failure of feedwater controls is another cause of boiler accidents, as is failure of cut-outs and water-level indicating devices on unattended boilers. In a large proportion of the cases the basic causes of these types of accidents are poor maintenance, absence of proper testing and lack of attention.

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Fuel explosions in the furnaces of power boilers have shown an upward trend in recent years. The principal causes of these explosions are initial ignition failure, flame interruption and power interruption. Specific causes include faulty wiring, defective contacts, wear of moving parts, short-circuiting of controls, leaky fuel-supply control valves, dirty burner and pilot light orifices and inadequate combustion air supply.

In concluding his paper Mr. Hardin suggested that control manufacturers give consideration to setting up performance standards for control devices, incorporate a "trouble shooting" section in operating instructions, and emphasize preventive maintenance, with employees regularly assigned to check equipment to see that it is in good operating condition.

"Automatic Data Recording and Annunciating for Power Plants" was the subject of a paper by **Stanley A. Kroll, J. G. Roback** and **J. S. Wapner** of Taller and Cooper Company. They described a device capable of observing and printing the sequence of operations under trouble conditions. This relieves the station operator of the function of keeping a log and provides an accurate schedule of station events listed sequentially in the order of their occurrence.

The equipment to accomplish the foregoing is made up of three components: (1) trouble contacts located on the individual equipment which is to be supervised and logged; (2) relay pulsing, coding, storing and decoding devices mounted in relay cabinets; and (3) the supervisory desk in the control room which contains the annunciator drop panel and the printing recorder.

At the Johnsonville Steam Plant of the T.V.A. means is provided to annunciate and record 400 possible sources of trouble. There are 26 banks of memory capacitors, which can be filled with a maximum of 26 operations in one third of a second. This information can then be recorded on a printer of the strip-chart type which permits the immediate reading of the recording. Audible and visible signals of faults are also provided for the operators.

Robert F. Cummings and **M. S. Umbenhauer** of Burns and Roe, Inc., discussed "Instrumentation at Danskammer Point Steam Station" of the Central Hudson Gas & Electric Corp. In the centralized control room of this station recording equipment for permanent records has been placed on a vertical panel directly in back of the boiler control panel with instruments located so that they may be viewed by the operator. Both the boiler and electrical control boards are of the benchboard type. Recording instruments not directly required for station control are placed in the back of the panel.

In the control room the general lighting level has been kept low, with dials provided with fluorescent coloring and black light to make them stand out. Considerable care has also been taken to establish a pointer pattern so that in normal operation all of the instrument pointers should be nearly in a straight line across the panel.

Chemists Discuss Air Pollution

The Manufacturing Chemists Association, through its Committee on Air Pollution Abatement, sponsored a two-day Conference, February 25–26, at the Hotel Statler, New York, to exchange technical information relating to air pollution abatement.

At the Monday morning session **J. M. Gillet** outlined the objectives of this committee as including a study of air pollution problems common to the chemical industry; the exchange of information; cooperation with other industry groups; and cooperation with public officials in attaining the best results at minimum cost to the community.

The Public Pays

New chemical plants, he stated, are being built which incorporate in the process equipment features that will avoid air pollution. A survey indicates that upwards of 35 million dollars was spent by the industry from 1946 through 1950 solely for equipment to abate air pollution. However, just as the major benefits from plant operation accrue to the public, so does the cost. If the cost be added to the selling price of the manufactured goods, the public pays the higher prices, but if the cost is taken out of company profits, the government loses in taxes, which loss must be made up by the general public.

While believing firmly in self-regulation in air pollution matters, the MCA Committee recognizes that conditions in some areas may require concerted action under government leadership.

Air Pollution Legislation

George E. Best, chairman of the Legislative Subcommittee of the MCA, presented the results of a three-year study of the laws now in effect and the varying nature of air contamination in a report entitled "A Rational Approach to Air Pollution Legislation." The purpose of the report is to create the framework within which a proper bill can be written if it is determined that a control law is wanted.

The fundamental basis for an air pollution law might be characterized as follows:

"Pollution of the atmosphere to the detriment of health or property shall be unlawful. This shall not be construed as contrary to the reasonable or natural use of air for dispersing waste products within the proper capacity to do so. Each localized area, i.e., affected by the same sources of pollution, shall be considered unique, and pollution within the area judged on the basis of its specific effects. The requirements for pollution reduction and control shall remain within the bounds of scientific knowledge and economic feasibility. The responsibility for proper control of emissions shall lie with the potential offender. Where community livelihood would be adversely affected by drastic reduction of air pollution, the right of local option is to be exercised in determining the extent to which reduction of pollution shall be required."

Seven principles were proposed for controlling air pollution:

1. Creation of a state bureau staffed with technical personnel.
2. Establishment of localized air pollution zones.
3. Appointment of local air pollution control commissions of representative community people for each local pollution zone.
4. Registration of points of emission—an inventory of air pollution.
5. Granting reasonable rights of entry to private property.
6. Action by the state bureau with the consent of the local control commissions to first recommend and then through the courts enforce specific requirements to achieve a particular objective.
7. Cooperation in technical advancement through the state bureau.

It was recommended that zoning regulations be framed to prohibit housing in designated industrial areas, this being one means of alleviating future air pollution problems. Provision for rapid amortization of facilities intended to curb air pollution was advocated.

Discussion

There was some disagreement as to the merits of establishing air pollution legislation at the state level. One objection was concerned with the complexity and difficulty of obtaining an adequate inventory of all pollutant sources in an area as large and varied as a state, and another dealt with the advisability of setting up such a necessarily complicated bureaucratic organization. On the other hand, it was argued that the average local commission would not have the resources in technical knowledge and manpower that could be provided in a state-wide agency. The MCA proposal leaves final control measures in the hands of local air pollution control commissions which have as their primary duty the correlation of the technical services of the state bureau with the viewpoints and needs of the pollution zone.

Air Pollution in New Jersey

"The New Jersey Problem" was discussed by **Dr. R. H. Daines** of the Rutgers University Experiment Station. Of thirty cases in that state in which air pollution was classed as an alleged threat to health, no instances were found in which it was demonstrated to have affected health adversely. However, Dr. Daines added that additional research on this subject is badly needed and that air pollution presents a "nuisance" value, whether or not it may be a demonstrable health hazard.

State air pollution legislation should incorporate provisions which respect local interests and should be formulated only after these interests have been ascertained. The possibility of arbitrary and capricious rulings is to be avoided. Wherever possible the legislation should encourage cooperation with industry, local communities and others concerned with air pollution.

A second paper on New Jersey air pollution was presented by **Dr. D. S. Bergsma** who spoke from the viewpoint of a public health administrator. He observed that more than 3,000,000 persons in this country suffer from hay fever and that a sound weed eradication program is an aid in the reduction of atmospheric pollution. He also mentioned that there have been some instances in which gaseous substances entrained in liquids and escaping from streams have caused an air pollution problem. Unless a definite hazard to health can be proved as resulting from air pollution, plants should not be forced to shut down. Public health departments may serve as an effective go-between for an aroused public and industry.

Abatement in the Steel Industry Requires Further Study

"Some Experiences with Air Pollution Abatement in the Steel Industry" was the title of a paper by **Dr. C. A. Bishop,** research associate of the U. S. Steel Corporation. While smoke abatement experiments in the Pittsburgh area have developed an effective method of smoke elimination in the case of some blast-furnace stacks, it was the speaker's opinion that further study and development of new methods by manufacturers of gas-cleaning equipment are necessary before the problem can be solved completely.

In a year the steel industry burns 17 million tons of coal under boilers and 94 million tons in coking plants, as well as more than a billion gallons of fuel oil and several hundred billion cubic feet of gas. For ferromanganese blast furnaces, which discharge large quantities of dense fumes, a steel industry committee developed a successful experimental plant to clean the smoke, reclaim the manganese and re-use the gas for fuel. In fact, such a plant has since been built to clean, commercially, 135,000 cu ft of ferromanganese blast-furnace gas per minute.

The steel industry committee in Allegheny County, working under an ordinance which provides for research into air pollution problems, has sampled the dust content of smoke from open-hearth furnaces, bessemer converters and blast-furnace slips. Although knowledge concerning air pollution from these sources has thus been increased, no satisfactory methods of prevention have yet been developed.

Effect of Contaminants

Dr. John H. Foulger of the E. I. du Pont de Nemours & Company discussed "Public Health and Air Pollution." He considered it unfortunate that most of the studies of the ill effects of air pollution have been confined to a single contaminant at a time. The possibility that a combination of contaminants might be additive in an exponential rather than in arithmetical sense must be considered in studying potential lethal effects. One of the principal aims of atmospheric control should be to reduce the amount of particulate matter upon which contaminants may collect.

Sensible Legislation Important

The problem of air pollution control involves not only technical difficulties but has sociological and economic aspects, **H. K. Dyktor,** commissioner of air pollution

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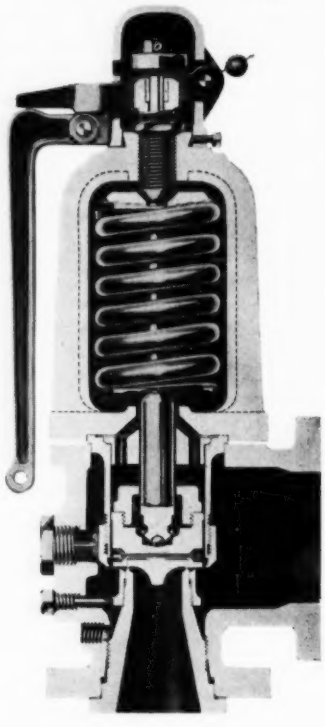

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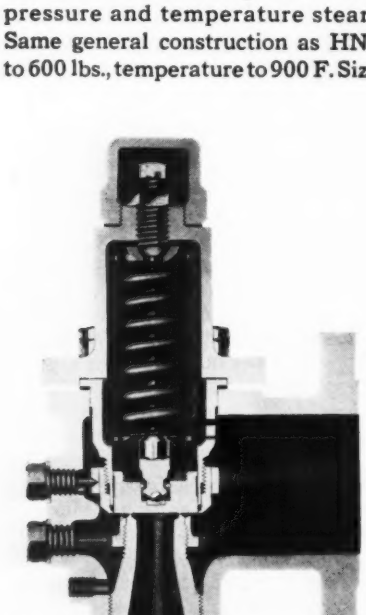

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control, Cleveland, Ohio, told those attending the dinner on Monday evening.

"The demand of people for a better life, which includes clean air, must be satisfied," he said. "We must also reckon with the position of industry which may be called upon to spend many millions for abating contamination. These expenses are generally added to overhead without tax relief.

"Complete elimination of air pollution is not expected by the people but substantial reductions are demanded. A tolerable level will have to be developed for each community so that both industry and people will be able to live together amicably, if not in complete comfort."

Mr. Dyktor added, "There are two ways to control air pollution: by restrictive and punitive legislation which seldom produces satisfactory results, or by sensible legislation, which will produce good results if used with education and persuasion. The type of legislation and administration is most important."

Planning Prevents Air Pollution

C. A. Gosline of E. I. du Pont de Nemours & Company believed that enough experience has been gained by the chemical industry to permit establishing procedures for avoiding future contamination. The key to successful planning for pollution abatement is recognition of the problem by management through willingness to pay for work necessary for developing solutions to waste problems and willingness to pay for translation of those solutions into equipment in the plant. In other words, more than lip service must be paid to the problem. The planning should begin in the research and pilot plant stages where the necessary data can be gathered.

When a site is selected for a new plant, studies should be made of topographic maps and wind directions to locate areas where high concentrations would be most critical.

Wind Tunnel Studies

Wind tunnel experiments with small scale models of factories are providing new information on how smoke can be effectively dispersed, according to **Dr. Gordon H. Strom,** associate professor of aeronautical engineering at New York University. Such studies reveal the influence of building configuration on stack gas dispersal. The ease with which a model can be modified is one of the advantages of such a method of investigation. Relocation of the stacks or the replacement of several stacks by a single stack are sometimes indicated as a beneficial change. In other cases the tests may show that improvement will be effected by increase in stack gas ejection speed sufficient to raise the plume out of the turbulent wake.

However, it is difficult to represent elevated stack gas temperatures in such wind tunnel experiments, and attempts to duplicate temperature and turbulence are now under way. The most difficult step is the simulation of meteorological factors important to gas dispersion.

Under the sponsorship of the Consolidated Edison Company of New York a wind tunnel was built at New York Uni-

versity for the study of gas dispersal problems and the work is now being continued under sponsorship of the Atomic Energy Commission.

Study of Contaminants

Dr. G. R. Hill of the American Smelting and Refining Company pointed out that complex air pollution problems are usually associated with population centers, where air pollution affects the health, comfort and use of property. To reduce air pollution it is necessary to identify the contaminants and their sources, determine the concentrations and study individual plants.

Equipment and methods are available for measuring some contaminant concentrations continuously and all contaminants by short-time sampling procedures. Directional samplers indicate the wind direction when contaminants are collected. Kite-balloons make possible studies in the lower atmosphere. After the contaminants and their sources have been identified, the next step is to study each individual plant to determine the most economical method of reducing the concentration.

"Cleaner air," said Dr. Hill, "will result only from cooperative community effort; and since the public pays for clean air, it must be realistic about the standards maintained in industrial areas."

Steam Turbine Output Unprecedented

Statements by the two largest manufacturers of steam turbines in this country not only reveal a record-breaking output last year but predict that these figures will be substantially exceeded during the current year, if the necessary critical materials are available in sufficient quantities.

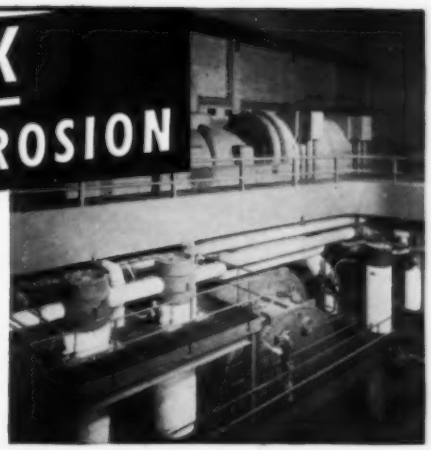
The General Electric Company's output in 1951 represented a nameplate rating of 4,098,000 kw, more than three-fourths of which went to electric utilities. Of the remaining capacity, 364,000 kw was built for industrial plants in the United States and 590,000 kw capacity was shipped abroad to allied nations. More than 36 per cent incorporated reheat.

These shipments, which are exclusive of merchant marine and naval units, were nearly five times the average of the three prewar years 1938, 1939 and 1940.

Nearly 99 per cent of the large unit capacity was built to operate at 900 F or higher and approximately two-thirds was in the 950–1050 F range. Furthermore, 66 per cent was designed for 1200 psig or higher and 14 per cent for 1800 psig or higher. Units shipped from Schenectady ranged from 20,000 to 112,500 kw.

Westinghouse reports that its Steam Turbine Division at South Philadelphia expects to turn out 3 million kilowatts capacity during 1952 which will be nearly double last year's record-breaking figure and four times the Company's best prewar production.

DON'T RISK SCALE AND CORROSION



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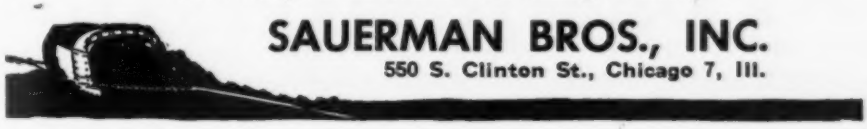

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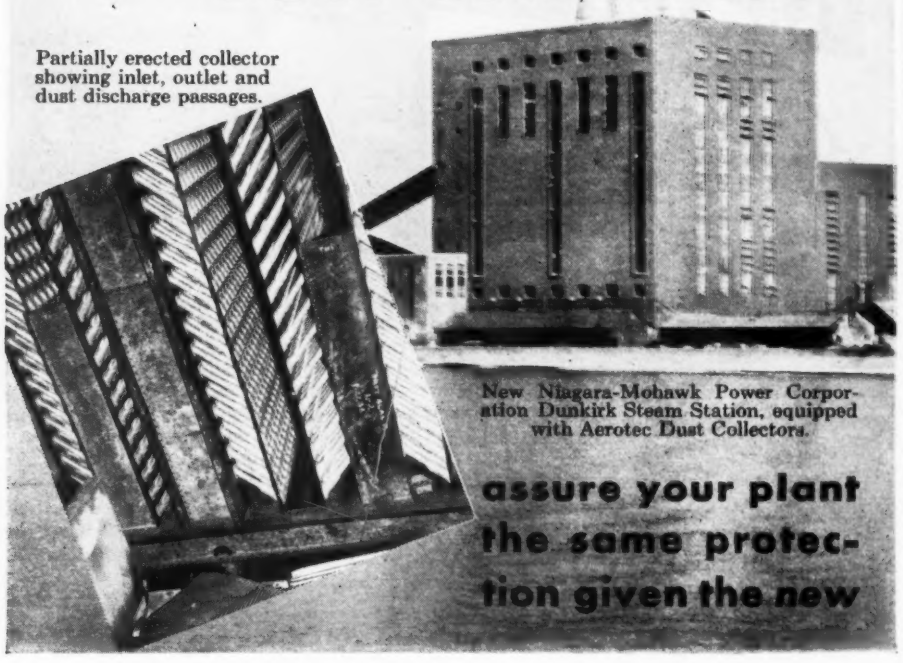
DUST COLLECTORS

Partially erected collector showing inlet, outlet and dust discharge passages.



New Niagara-Mohawk Power Corporation Dunkirk Steam Station, equipped with Aerotec Dust Collectors.

assure your plant the same protection given the new

NIAGARA MOHAWK POWER CORPORATION

Dunkirk Station . . . and a duplicate Albany Plant

At the new Dunkirk Steam Station of Niagara Mohawk Power Corporation, two reheat steam generators of 670,000 lb. per hour capacity are pulverized fuel-fired. Dust collection for this station is handled by Aerotec, Design 3 RAS Collectors, and a duplicate system is under construction for the new Albany Steam Plant . . . making a total of eleven Niagara Mohawk boilers to be equipped with Aerotec Dust Collectors.

The collectors for Dunkirk and Albany consist of 84 "Unit Building Block" elements completely assembled at the factory for easy erection in the field. The small diameter tubes, of permanent molded aluminum construction, have proved their extremely high collection efficiency and long life on hundreds of installations. Their light weight cuts steel requirements for supporting structure, and makes possible roof installations with a minimum of reinforcement. The light weight tubes also reduce erection costs.

Aerotec efficiencies meet or exceed the requirements of most dust ordinances today. Evenly spaced tube outlets provide excellent inlet flow conditions for an AEROTEC electrical secondary—should future ordinances require still higher efficiencies.

Write for the new Design 3 RAS Catalog No. 601.

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Manufacturers of mechanical dust collectors, electrical precipitators, air cleaners, industrial integral dust collectors, gas-oil scrubbers and dust reclaiming equipment.

ASME Spring

THE 1952 Spring Meeting of the ASME will be held at the University of Washington, Seattle, Wash., March 24–26. A total of 45 papers will be presented by 51 authors at 17 technical sessions sponsored by 13 of the ASME professional divisions.

Governor Arthur B. Langlie of the State of Washington will present the address of welcome at the President's Luncheon on March 24, following which ASME President R. G. S. Pigott will speak on "Are We Self-Supporting in Energy Supply?" At the banquet on March 25, Roderic Olzendam, director of Social Security for the State of Washington, will have as his subject "Human Engineering."

Portions of the program expected to be of interest to those in the steam power field include the following:

Monday, March 24, 9:30 a.m.

"Broom Closets or the Effect of Maintenance Upon Design of Steam Power Plants," by B. C. Mallory and F. W. Argue, Stone & Webster Engineering Corp.

"Etiwanda—A Study in Overall Steam Station Economy," by W. L. Chadwick, Southern California Edison Co., and E. H. Krieg, Stone & Webster Engineering Corp.

Monday, March 24, 12:15 p.m. President's Luncheon

"Are We Self-Supporting in Energy Supply?" by R. J. S. Pigott, president of ASME.

Monday, March 24, 2:30 p.m.

"Technical and Commercial Factors Relating to Trans Mountain Oil Pipe Line," by D. L. Roberts, Canadian Bechtel Ltd.

"Design and Construction of Pacific Gas & Electric Company's 34-Inch Gas Line," by J. J. Pugh, Pacific Gas & Electric Co., and Ray Hamilton, Bechtel Corp.

Monday, March 24, 8:00 p.m.

"Ventilation Problems in Safe Handling of Radioactive Materials," by W. W. McIntosh, General Electric Co.

"The Handling of Radioactive Materials," by E. Hollister, General Electric Co.

"Problems of Technical Training for Nuclear Energy," by B. T. McMinn, University of Washington.

"What Do We Mean by Nuclear Engineering?" by D. W. McLenegan, General Electric Co.

Tuesday, March 25, 9:30 a.m.

"Burning Sulphite Waste Liquor," by H. A. Sorensen, The State College of Washington.

"Turbulent Burning of Wet Wood, Bark and Other Fuels" by Otto de Lorenzi, Combustion Engineering-Superheater, Inc.

"Steam Turbine Generators for Indus-

Meeting Program

trial Plants—Their Design, Application and Controls" by S. D. Fulton, Westinghouse Electric Co.

Tuesday, March 25, 12:15 p.m. Roy V. Wright Luncheon

"Engineers' Civic Responsibility—An Action Program," by Prof. B. M. Woods, University of California.

Tuesday, March 25, 6:30 p.m. Banquet

"Human Engineering" by Roderic Olzendam.

Wednesday, March 26, 9:30 a.m.

"The Free Piston Engine Development—Present Status and Design Aspects," by A. L. London, Stanford University, and A. K. Oppenheim, University of California.

"The Pattern of Gas Turbine Development in Europe and the U. S.," by F. T. Hague, Westinghouse Electric Corp.

Wednesday, March 26, 2:30 p.m.

"Waste-Wood-Fired Gas-Turbine Power Package," by G. H. Atherton, Oregon Forest Products Laboratory.

"The Function of a Boot-Strap Gas-Turbine Unit in University Work" by M. Guidon, University of Washington.

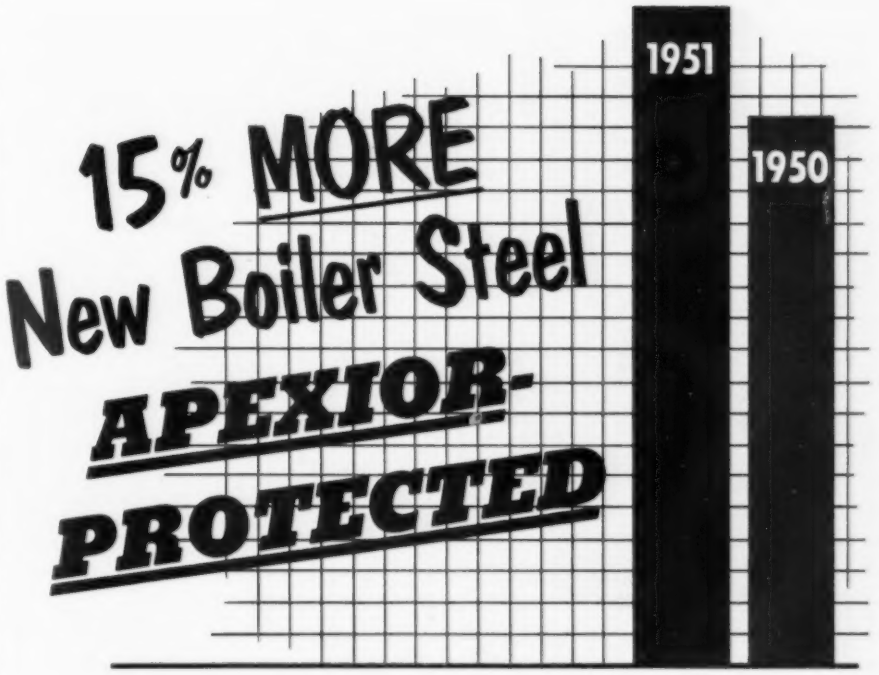
British Power Station Construction

Reporting on British electric generating construction during 1951, *Engineering* (London) of January 11 quotes Lord Citrine, chairman of the British Electricity Authority as saying that, despite the priorities situation regarding materials, additional capacity of 1,113,000 kw was placed in service last year. Of the 25 stations involved, ten were new. Several of these new stations employed the unit system of one boiler per turbine. The further addition of 1,550,000 kw has been authorized for installation during 1952.

It would appear that during the winter of 1951–1952 there was a marked reduction in the number of times load had to be shed for lack of capacity. This Lord Citrine attributed to more attention having been given to load spreading, which reduced peak demand by about 500,000 kw and to an intensive program of overhauls earlier in the year which increased the general availability.

The question of receiving assistance from Norway and France had been looked into, but present limitations on the transmission of power by submarine cable had precluded the former and it was found that the peak loads of Britain and France coincided; also, that there is rationing in parts of France.

Work is now in progress on the construction of one semi-outdoor station, in connection with which it is proposed to investigate the effects of British climate on its operation before deciding whether this type of construction should be extended.



That's how the record for '51 compares with '50 — a gain of 15% in square feet of new-boiler heating surface Apexior-coated, in manufacturing plants, central stations, institutions and government facilities — evidence of continued and growing recognition of the benefits of internal boiler surfacing.

Many another theory of boiler operation or maintenance has found favor over the years, flourished for a time, and been superseded by some still newer idea. Such others as scientific feedwater control have permanently altered boiler operating techniques. Yet now for more than thirty years, throughout practically the entire development of high-pressure steam generating knowledge and practice, APEXIOR NUMBER 1 has continued to serve its unique function.

Simply by adding a smooth, moisture-impervious film that keeps tubes and drums sound and clean, APEXIOR frees steel from the inevitable variations of normal boiler operation. Thus stabilized for lasting "new-metal" performance, the APEXIORized boiler gives you longer, better service, at less cost.

Helping steel produce power more abundantly and efficiently is the function, too, of other Dampney coatings — ceramics and silicones, for high-heat service; vinyls, asphaltums and chlorinated rubber . . . all equipment-engineered for highly specialized service. Let us put our experience and facilities to work on *your* metal maintenance requirements.

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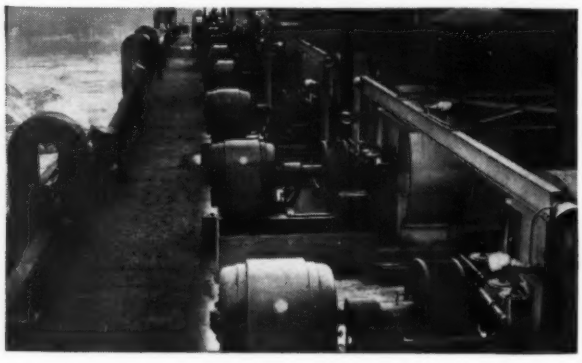
Twenty-four large Green Fans take care of a heavy draft load at the Venice (Illinois) Plant of the Union Electric Co. of Missouri. Each of six boilers has two sets of Green Fans, each set consisting of one induced draft fan and one forced draft fan coupled to one motor as a unit. With the heavy demands on this station, all boilers are usually in service continuously, thus throwing an unrelenting burden on the fans.

Engineers whose responsibility it is to recommend or accept draft fans for large power plants certainly want efficiency and low operating costs. But they don't overlook the maintenance and replacement angles. They want the sound designs of competent experienced fan engineers. They also want the care in construction that is found in shops of a company that has built up an international reputation as the "authority" on draft fans. They know that such a company will not tolerate sloppy shop work.

Green is this authority on mechanical draft fans.



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New Books

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Energy Sources—The Wealth of the World

By Eugene Ayres and Charles A. Scarlott

The need for a semi-popular, comprehensive compilation of world energy resources is met by this interestingly written book. It begins with an account of the geological history of fuels and then takes up the principal renewable and nonrenewable sources of energy. Chapters entitled "How Much Petroleum," "How Much Coal" and "How Much of Other Fossil Fuels" provide statistics on production, demand and reserves of these fuels.

Transformation of one fuel to another and trends in energy use are considered at some length. A chapter entitled "Life Expectancy" analyzes some of the possibilities in the future energy picture. Potential methods of utilizing the energy of the sun, wind and tides are described, and the prediction is made that the conversation of solar energy to power may be the largest energy development of the future.

The last chapter, "Energy Balance Sheet," written by R. C. Widgery, contains tables showing the production of mineral fuels, water power and wood in the United States from 1800 to 1949. Other tables list amounts of primary and secondary fuels entering fuel-converting and energy-consuming operations in the U. S. in 1947 and the energy equivalents of these fuels.

An appendix includes a lengthy list of conversion factors for fuel and power and an 11-page bibliography.

Originally prepared as a paper for the American Petroleum Institute, the material has been expanded by Mr. Ayres, who is with the Gulf Research & Development Company, and by Charles A. Scarlott, editor of *Westinghouse Engineer*. The book contains 344 pages and sells for $5.

Engineers' Illustrated Thesaurus

By Herbert Herkimer

This unique book contains more than 8000 schematic and diagrammatic illustrations of machine elements and assemblies. Its underlying purpose is to emphasize basic principles of machine and product design and to suggest ideas to the prospective designer or inventor.

The author has adopted a classification similar to that of Roget's *Thesaurus of English Words and Phrases*. There are twelve classes, three under statics and nine under dynamics, as follows: fasteners; adjusting devices; supports and structures; basic mechanical movements; elevators, derricks, cranes and conveyors; transmission of liquids and gases; combustion; prime movers; transportation; industrial processes; electrical appliances; comfort heating, cooling and air condition-

ing. Each of the classes is divided into a number of sections. In addition there is a detailed index of the elements shown in the book.

Although the illustrations are necessarily small, they are adequate to serve their function of suggesting solutions to design problems and to stimulate creative thinking. In a number of cases there are explanations of how particular machine elements accomplish their special functions.

The book contains 572 pages and sells for $6 per copy.

Piping Design and Engineering

First Edition

To quote from the foreword, the purpose of this handbook prepared by Grinnell Company, Inc., was "to compile in a single publication engineering data and technical information for the use of engineers engaged in the design and application of pressure piping hitherto available only by consulting a number of sources." Stated broadly, the contents include code requirements, expansion and stresses, velocity and pressure drop, heat transfer, pressure-temperature pipe graphs, metallurgical briefs, piping materials and fabrication, hangers and supports, deflections, etc. This text is supplemented by numerous tables, general and specific layout diagrams and charts to facilitate calculations. The size of the book, $8^1/_2 \times 11$ in., has made it possible to reproduce the charts sufficiently large to permit close reading. Futhermore, solutions to various typical problems are incorporated in the text. This book of 221 pages is exceptionally well printed on good stock and is priced at $10.

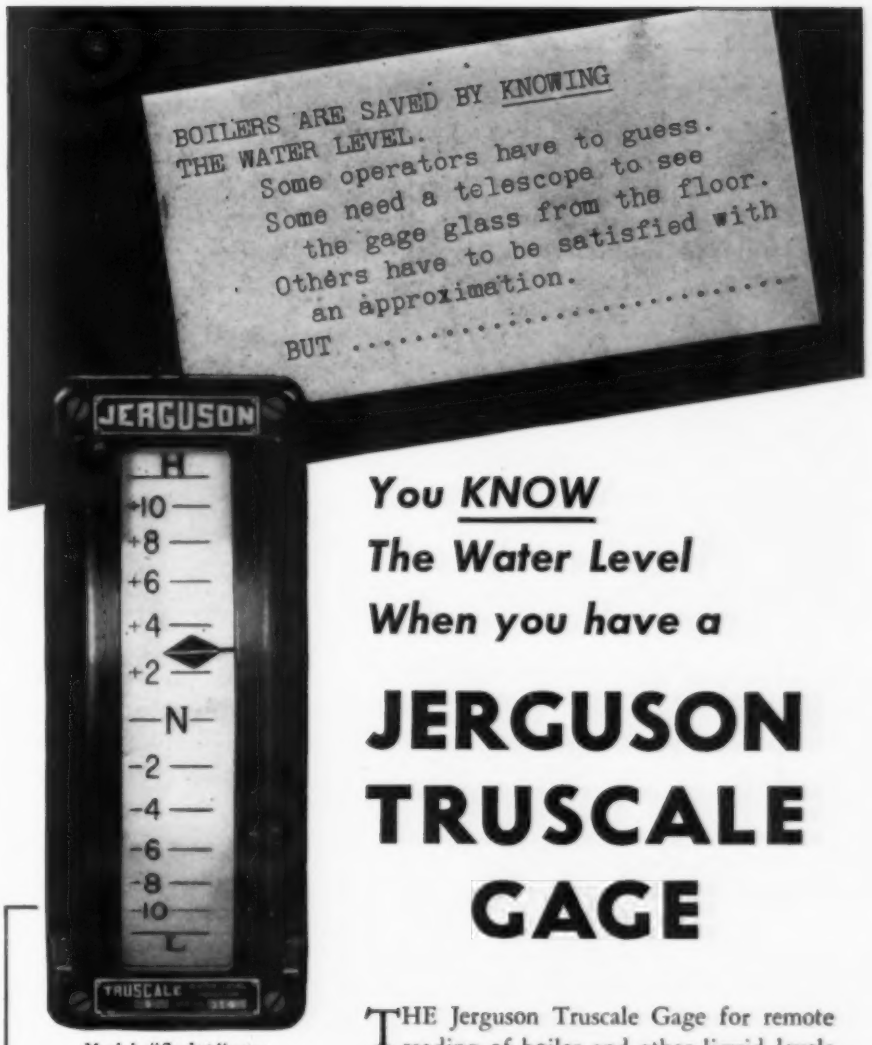
Electric Power and Social Policy

By W. H. Connor, B. Cross, H. Evans and H. Tannenbaum

Subtitled "A Resource Guide for Teachers and Discussion Leaders" this pamphlet is the outcome of a workshop on electric power conducted by Teachers College of Columbia University during the summer of 1950. The major objectives of the workshop were: (*a*) to inquire as fully as possible into the nature, organization and operation of the electric power industry; (*b*) to explore the technical base underlying the industry and to discover its relationship to the whole of American technology; (*c*) to prepare a resource guide on electric power for use in schools and other community groups.

The titles of the five chapters give some idea of the scope of the pamphlet: Electric Power and Education, The Widespread Use of Electric Power and Its Social Impact, The Technical Base of Electric Power, Electric Power—A Strategic Industry, and American Technology and Social Policy—Major Issues.

The objection has often been raised that social science textbooks for the classroom have given a biased picture of the electric power industry. However, that is not



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THE Jerguson Truscale Gage for remote reading of boiler and other liquid levels is ACCURATE to ½ of 1% of scale reading.

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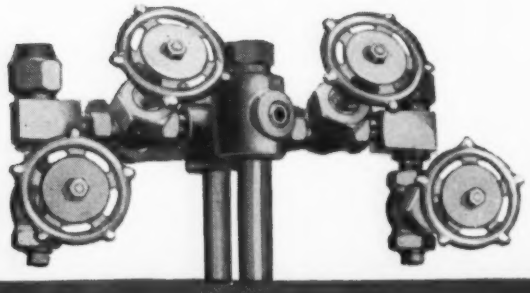

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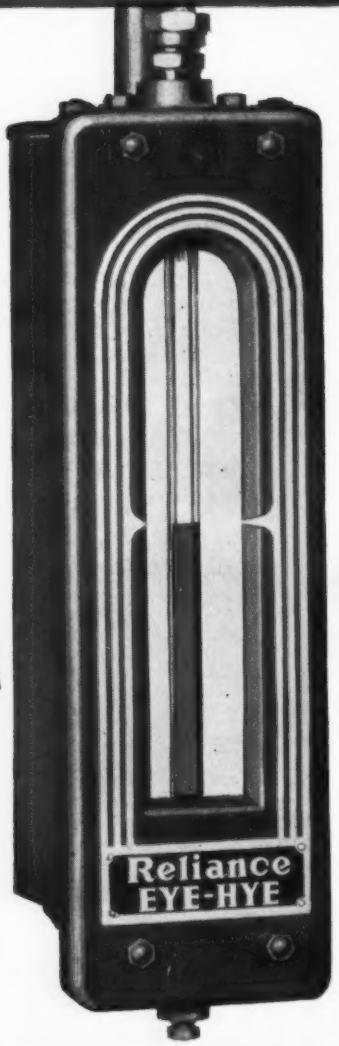
EYE-HYE Remote Reading Indicator

Gage reading at eye-height any reasonable distance from drum

Easy to read, like conventional gage

Illuminated green fluid gives sharp clear indication



Simple, manometer principle, no complicated working parts

Easy to install, practically no maintenance

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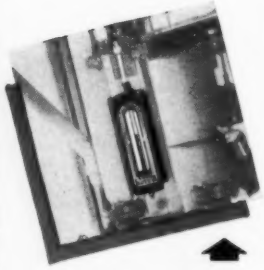

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true in this instance. This well-illustrated, objectively written pamphlet sets forth the problems and the issues in a clear, understandable manner. The achievements of the electric power industry are appropriately recognized, and the question of who should control electric power is discussed impartially.

The 60-page paper-bound pamphlet includes a short bibliography and sells for $0.75.

Corrosion Testing

By Francis L. LaQue

This 1951 ASTM Edgar Marburg Lecture comprises a survey of corrosion-testing programs and methods of corrosion testing, many of which have been sponsored by the American Society for Testing Materials. Mr. LaQue, who is in charge of corrosion research and development for the International Nickel Co., is a well-known authority on the practical aspects of corrosion phenomena. He here discusses the distinction that must be made between the corrodibility of a material and the protective value of its corrosion products and how these are influenced by both the composition of the material and the incidental conditions of its exposure.

Some of the topics touched on in the book are: atmospheric corrosion studies; relations between rust color and corrosion; effects of alloying elements on the resistance of steels and irons to atmospheric corrosion; comparison of atmospheres; and galvanic corrosion. Also discussed are a variety of tests such as: acid, accelerated, atmospheric galvanic, salt spray, laboratory total immersion and alternate immersion, boiling nitric acid, plant corrosion, paints, etc.; tests in waters; corrosion tests of insect screens; long-time tests of different steels and irons; and effects of position in test.

This 96-page booklet, with heavy paper cover, sells for $1.50.

TVA Refused Use of Gas

The Federal Power Commission has handed down a decision on use of fuel resources that may have great significance for the future. It has rejected the application of a natural gas distributor to sell gas to the Tennessee Valley Authority for use as a fuel under the boilers of the new Johnsonville electric generating plant.

The Commission pointed out that TVA is close to vast deposits of bituminous coal; that coal has always been available for its steam-electric generating plants; and that coal producers have offered to supply far larger tonnages than TVA can use. Hence, the Commission declared, there is no reason to doubt the abundant availability of coal in the future.

Although the gas distributor is reported to have offered his fuel at a lower price, the Commission made this observation:

"The relatively small money savings which might accrue from use of natural gas does not justify authorization to use as boiler fuel an amount of gas that would be greatly in excess of the requirements of all the consumers in the Washington, D. C., area."

Vogel and Hatfield Named Vice Presidents

Combustion Engineering-Superheater, Inc., has elected Wiliam J. Vogel and Robert M. Hatfield as vice presidents. The former was employed by the Company in 1924 and has been an executive of the Engineering Department for some years past. He was appointed assistant chief engineer in 1940 and chief engineer in 1950. He will continue in the latter post, working in association with W. H. Armacost, vice president in charge of engineering.

W. J. Vogel

Mr. Hatfield joined the Company in 1934. He was appointed general manager of its Western Division in 1949 and will continue in this post with headquarters in Los Angeles. During World War II, he was on loan to the Federal Government, serving in various capacities in the War Production Board, his final post at that time being that of Deputy Vice Chairman for Production in charge of production for all war industries. In October 1950 his services were again requested by the Government to organize and head the Power Equipment Division of N.P.A. He resigned from this position in March 1951, but was once again recalled to Washington in July to accept appointment as Vice Chairman of the Munitions Board, which post he recently relinquished.

R. M. Hatfield

For Safer, Surer Supervision of boiler water levels--
Reliance Water Columns and Complete Gage Equipment
Forged steel strength far exceeding code requirements—Reliance Columns for pressures to 2000 lbs.; with alarms, to 900 lbs.
Precision-made gage inserts for all pressures. (Mica-protected flat glass or all-mica windows.) Sizes for all visibility lengths.
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No. 503. Cast iron base construction suitable for pressures up to 250 lb. Cast steel base construction suitable for pressures up to 400 lb.

Bulletin 4-A explains in full what ATLAS damper regulators do and why hydraulic operation is best. Drawings show all parts and how the regulators are constructed. Drawings also show typical hook-up arrangements and regulator combinations. It is a bulletin that is worth studying, using, and keeping in your files.

The coupon below will assist in obtaining Bulletin 4-A as well as data concerning other ATLAS regulating devices. We have been in the regulation business *exclusively* for more than a half century.

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Personals

John M. Drabelle, chief engineer of the Iowa Electric Light and Power Company, Cedar Rapids, Iowa, will retire on April 1 after approximately 42 yr of service. He is well known for his activities in central station and engineering society affairs.

Forrest Nagler, formerly chief mechanical engineer of the Allis-Chalmers Development Division and since 1949 manager of its Atomic Power Division, retired on March 1. He is widely known as the inventor of the Nagler type of axial-flow high-speed hydraulic turbine runner.

Donald E. Dixon, formerly superintendent of power at the Gunnison, Colorado, municipal power plant and for the last two years chief engineer of the Trinidad, Colorado, municipal power plant, has joined the Hagan Corporation as service representative for automatic combustion controls and water treatment in the Denver district.

Martin E. Gilwood has been named director of research by The Permutit Company, New York.

Robert J. Mindak, assistant research engineer for the Standard Oil Company of Indiana, has been appointed an associate engineer in the heat-power department at Armour Research Foundation of the Illinois Institute of Technology.

William J. Fitzburgh was recently elected president of Diamond Power Specialty Corporation, taking the place of W. P. Thomas who became chairman of the board. Mr. Fitzburgh, a Stevens graduate joined the company in 1929, serving successively as a sales engineer, chief engineer, assistant to the president, and for the last two years executive vice president.

Phil Sprague, Jr., has been appointed executive vice president of The Hays Corporation, Michigan City, Indiana. He is succeeded as advertising manager of the Company by Paul B. LeBoeuf, formerly with the A. O. Smith Corporation.

H. Stanley Bimpson has been appointed chief engineer of the steam turbine section of Allis-Chalmers Company. He was formerly a consulting engineer in the Company's general machinery division.

Zay B. Curtis, Jr., formerly assistant plant manager of the Fostoria Pressed Steel Corporation and lately works manager of Hamilton-Thomas Corporation, has been appointed assistant to the president of C. H. Wheeler Manufacturing Company, Philadelphia.

New British Station Employs High Pressure and Temperature

A new British power station, "Drakelow-A," now under construction and described in *Engineering* of February 15, is designed to accommodate four 60,000-kw turbine-generators arranged on the unit system. Each will be supplied with steam at 1550 psig and 1060 F by a 515,000-lb per hr radiant-reheat boiler of International Combustion, Ltd. design employing tangential firing with tilting burners. The fuel will be pulverized coal of 10,200 Btu per lb calorific value analyzing 25 per cent ash. When burning this fuel at maximum continuous rating and with a moisture content of 14 per cent, an overall efficiency of over 85 per cent is anticipated.

A similar plant, "Drakelow-B," will soon be erected adjacent to the first.

Air Pollution Symposium

A second National Air Pollution Symposium will be held May 5 and 6 at the Huntington Hotel, Pasadena, California. Under sponsorship of Stanford Research Institute, in cooperation with California Institute of Technology, the University of California at Los Angeles, and the University of Southern California, sessions will follow the general pattern of the successful first symposium held under the same auspices in 1949.

Dr. A. M. Zarem, chairman of the executive committee, states that the program will cover general topics of new techniques in sampling, analysis and instrumentation, fundamental chemistry and physics of the atmosphere, the contribution of internal-combustion engines and biological aspects of atmospheric contamination.

Management's views on air pollution will be introduced in the hope of a better understanding of the necessary contributions of industry and science toward the achievement of tolerable limits of air contamination.

Sunset on the Harlem

The cover photograph in this issue is the work of a sixteen year old Brooklyn boy, Stuart Umin, a member of one of the camera clubs sponsored by the New York City Police Athletic League. Stuart, who has been an active club member for three years, attends the School of Industrial Art and was awarded two prizes at the recent Sixth Annual Photo Show of the P.A.L. COMBUSTION wishes to express its appreciation to James B. Nolan, deputy police commissioner and president of P.A.L. and to Victor Keppler, director of P.A.L. camera clubs, for their cooperation in providing this opportunity to show one accomplishment of this promising young industrial photographer.

Round and round he goes, and when he stops this inspector will have completed examination of a line-up of synchronous motor stator frames at General Electric's large motor and generator department, Schenectady, N. Y. In ratings ranging from 100 to 500 hp, the finished motors will be used to drive such equipment as pumps, compressors, rolling and crushing mills, hoists, conveyors, generators and fans.

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- High and Low Alarm Columns
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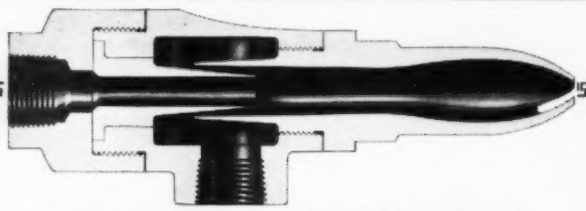

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The popular NATIONAL AIROIL Steam Atomizing Oil Burner *thoroughly atomizes* and *completely burns* the lowest and cheapest grades of fuel oil or tar . . . requires minimum supervision and maintenance. Only slight oil pressure and temperature is needed . . . and internal atomizing venturi feature assures low steam consumption.

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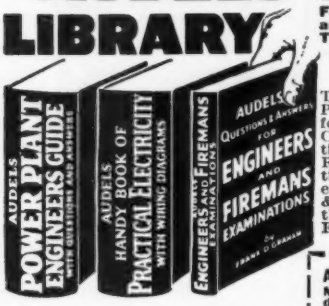

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